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## ABSTRACT

The purposes of this report are to assess the need for federally supported curriculum development in education, and if there is a need, to determine appropriate policies for conducting development and supporting implementation. The assessment is based on the national curriculum development projects that have been sponsored since 1956 by the National Science Foundation. The study is intended for use by federal policy-makers and others in considering the role of national curriculum development in improving the quality of education and in determining strategies for supporting the development and implementation of school curriculum innovations. Topics covered include (1) national curriculum projects and their effect on the classroom, (2) institutional factors favoring maintenance of the existing curriculum, (3) effects of national curriculum development on institutions, (4) effects of federal curriculum programs on commercial curriculum, and (5) federal support of school-level implementation activities. The basic premises that the school curriculum is influenced by the interrelationships of the publishing industry, the state adoption committee, and local school districts, and that national curriculum development changes the character of the institutions and the way they interact with one another, were supported. Also included are further research directions and tables indicating specific changes in science curricula. (Author/JK)

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January 1979

NATIONAL CURRICULUM PROJECTS AND DEVELOPMENT IN EDUCATION

Joan Marks

A WORKING NOTE  
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PREFACE

The purposes of this report are to assess: (1) the need for federally supported curriculum development in education, and (2), if there is a need, appropriate policies for conducting development and supporting implementation. The assessment is based on the national curriculum development projects that have been sponsored since 1956 by the National Science Foundation. The study is intended for use by federal policymakers and others in considering the role of national curriculum development in improving the quality of education and in determining strategies for supporting the development and implementation of school curriculum innovations.

This study extends previous Rand research on the implementation process in local school districts to include development and to include other institutions influencing innovation in education. Curriculum change is viewed as a process of interactions among curriculum innovations (technology), institutions, and their environments.

For a list of previous Rand research on educational innovation, see Paul Berman and Milbrey McLaughlin, *Federal Programs Supporting Educational Change, Vol. VII: Factors Affecting Implementation and Continuation*, The Rand Corporation, R-1589/7-HEW, April 1977.

This study was supported by a research grant from the School Capacity for Problem-Solving Group of the National Institute of Education (NIE-G-74-0069), and was initially issued as a discussion draft in 1977, written by John Wirt and Suzanne Quick. The current version, prepared by Joan Marks, is a summary of the earlier draft.

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## I. INTRODUCTION

The *quality of education* was a major public concern of post-World War II America. Increased numbers of war babies reached school age only to find the schools not prepared to teach them.\* There were too few school buildings and qualified teachers to meet the burgeoning population's educational needs. Teachers were in such a short supply that schools were not able to fill positions with qualified personnel.

For example, a report submitted to President Eisenhower stated that the numbers of science and mathematics teachers being trained could not "...even provide for normal replacements at the present level, let alone take care of foreseeable growth."\*\* Most important was the fact that America emerged from the war as a much more complex and technologically oriented society and was in a race for supremacy with the Soviet Union.

This educational crisis was articulated in *Soviet Science Manpower*, a book published by the National Academy of Sciences, which greatly alarmed Congress.\*\*\* Academic professors suddenly found their services in demand by the federal government. Scientists had been successful in the Manhattan project and other war-related activities. There was an increasing belief that formal knowledge could make a significant contribution to the formulation and execution of public policy.†

Academics said high school graduates were ill-prepared to handle even the most basic university courses. They blamed publishers'

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\* Lawrence A. Cremin, *The Transformation of the School*, Vintage Books, New York, 1964, p. 338.

\*\* Hillier Kreighbaum and Hugh Rawson, *Investment in Knowledge*, New York, University Press, 1964.

\*\*\* Op. cit., p. 164.

† Peter B. Dow, "Schooling and Society: Some Historical Perspectives on the Science Curriculum Reform Movement," Harvard University, unpublished paper, September 1975.

materials, teaching practices, and teacher training programs.\* Publishers' materials were criticized as collections of miscellaneous facts devoid of unity and often seriously out-of-date, if not scientifically erroneous. Arthur E. Bestor charged in his book *Educational Wastelands* (1953)\*\* that the post-Dewey progressives had so involved the schools in vocational activities and child-centered learning that basic academics were neglected. These concerns evoked a strong response in parents concerned about their children's future as they perceived education as essential for success.

However, the federal government was not in a position to offer assistance to education. Ever since the 1880s bills for federal aid to education were defeated when introduced in Congress.\*\*\* The people feared that federal money would lead to federal control of education--that educational freedoms would be subordinated to the needs of the state.

For example, in 1950 a major education bill died in the House Education and Labor Committee despite passage in the Senate and strong support from President Truman. Committee Chairman John Lesinski said:

I have supported federal aid. I believe that a majority of this committee believes in federal aid. But I am convinced, after hard study we have put to the question, that no acceptable bill preventing federal dominance of local schools can be drawn. I reluctantly come to that conclusion, but I have to face the facts. This is the reason we have failed to report a bill.†

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\* National Science Foundation, "The Role of the National Science Foundation in Course Content Improvement in Secondary School," *School Review*, Vol. 70, No. 1, Spring 1962, p. 5; and Paul deHart Hurd, *New Directions in Teaching Secondary School Science*, Rand McNally, Chicago, 1971, p. 3.

\*\* Lawrence A. Cremin, op.cit., p. 343.

\*\*\* Stephen K. Bailey and Edith K. Mosher, *ESEA The Office of Education Administers a Law*, Syracuse, 1968, p. 21.

† *Elementary School Journal*, Vol. 50, May 1950, p. 486, as quoted in Peter B. Down, op.cit., p. 52.

The flight of Sputnik I in October 1957 broke congressional resistance to funding education. Sputnik confirmed the belief that the United States was behind the Soviet Union in education and manpower. President Eisenhower responded to this emergency by urging Congress to authorize federal assistance to education. This move was provoked by the prevailing sentiment that the nation's future was tied to education. The emergency educational program he proposed included expanding the National Science Foundation's (NSF) science education activities as well as the passage of the National Defense Education Act.\*

Eisenhower stressed the *transient* and *emergency* nature of his proposed program. He believed education was a responsibility of the state rather than the federal government. He promised that once this crisis passed federal financing for education would cease. The president's arguments were persuasive; in 1958 the National Defense Education Act became law.\*\*

#### THE NATIONAL SCIENCE FOUNDATION'S PROGRAM

The National Science Foundation had been working to improve education since 1953 by sponsoring "scientific institutes." High school science teachers were invited to university-based institutes for an updating of knowledge in their teaching speciality. These institutes eventually grew to be the major component of the NSF's educational program.

The first curriculum development program originated with Jerrold Zacharias of the Massachusetts Institute of Technology and was called the Physical Sciences Study Committee (PSSC). Zacharias invited distinguished university scientists and high school physics teachers to participate. Their purpose was to make advanced scientific principles comprehensible to everyone. Work soon began on an updated student text, a laboratory manual and equipment, a film series, achievement tests, a teacher's guide and resource book, and a series of paperback

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\* Dwight O. Eisenhower, *Recommendations Relative to our Educational System*, Address to Congress, January 27, 1958.

\*\* Elder Witt, et al., *Education for a Nation*, Congressional Quarterly Inc., Washington, D.C. 1962, p. 63.

books providing authoritative science literature for students and adults.\* These materials were tested and revised in ordinary classrooms following formative evaluation procedures.

When the 1958 Education Act passed, NSF had four projects. Following the PSSC model, the Biological Science Curriculum Study (BSCS), the Chemical Bond Approach (CBA), the Chemical Education Materials Study (CHEM Study), and the School Mathematics Study Group (SMSG) were launched. A wave of expectation swept across the country. Most people thought that the revolution in science and math education would solve many of education's problems. Let us examine what effect it did have on education.

### Project Objectives

The high school projects focused on subject matter while the elementary projects were more sensitive to pedagogy. Teacher training in science methods became an important objective of the elementary school projects.\*\* Up until this time, little or no science had been included in the elementary school curriculum. Teachers were not sure what were the best methods for teaching the new subject matter.

Many other national curriculum projects were initiated in the years after the elementary schools projects, as shown in Table 1.1. and Fig. 1.2. These projects first aimed at improving the existing discipline-oriented courses and then shifted to producing problem-oriented courses. Socially important problems were examined by considering knowledge from many different scientific disciplines. This approach involved integrating diverse knowledge into one course of study. The science curriculum was reorganized to fit a problem-oriented framework.

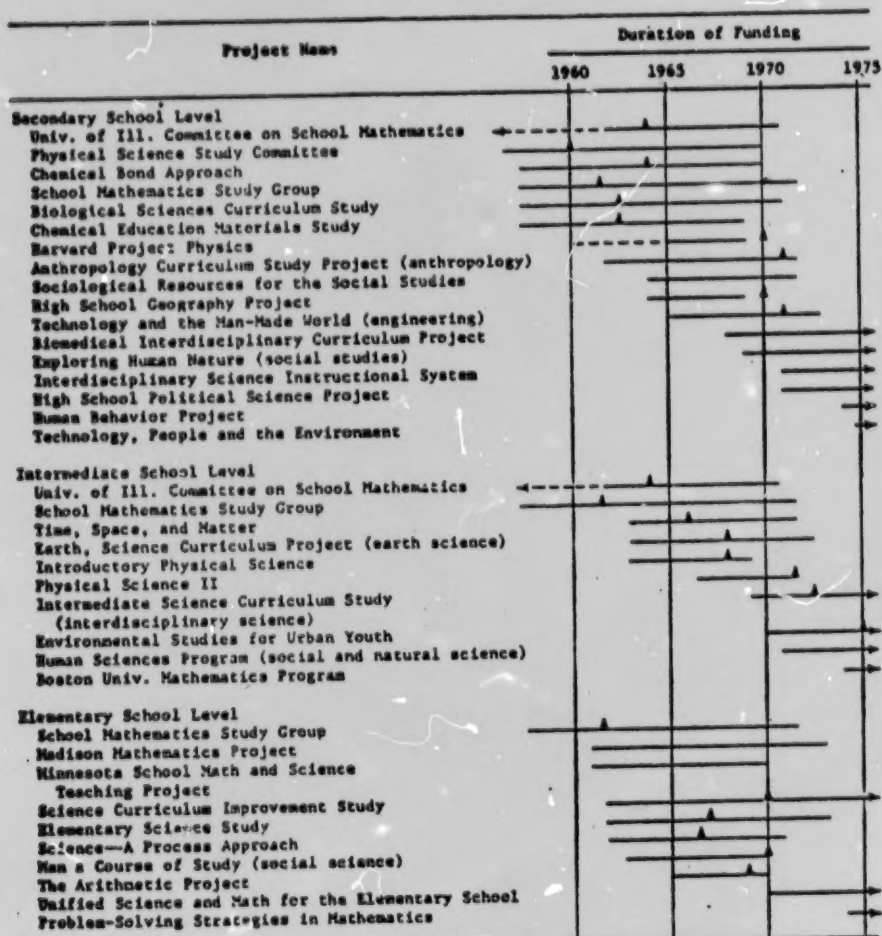
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\* Gilbert G. Finley, "The Physical Science Study Committee," in *Modern Viewpoints in the Curriculum*, Paul Rosenbloom (ed.), McGraw-Hill, New York, 1964, p. 38.

\*\* "Science Teaching in Elementary and Junior High School," *Science*, Vol. 133, June 23, 1961, pp. 2019-2024.



Table 1.1  
MAJOR NATIONAL CURRICULUM DEVELOPMENT PROJECTS  
OF THE NATIONAL SCIENCE FOUNDATION



Key: — NSF Funding  
 -- Other Funding (Office of Education, foundations)  
 ▲ Copyright date of first edition of commercial materials

SOURCES: National Science Foundation, "Course Curriculum Improvement Projects," O-347-631, Washington, D.C., 1974; "Pre-College Science Curriculum Activities of the National Science Foundation," Vol. II, pp. 171-176; and *EL-hi Textbooks in Print*, R.R. Bower, for years 1965, 1970, and 1975.

### Total Funding

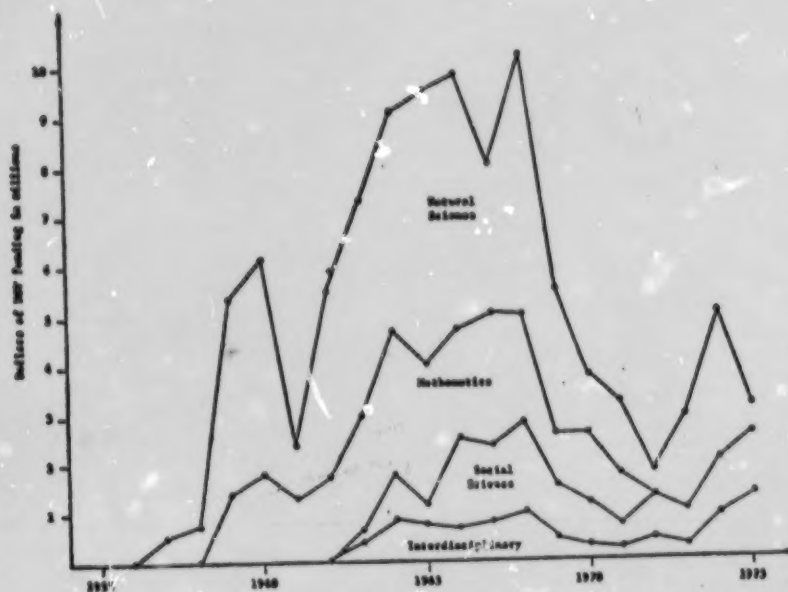
NSF has supported more than forty national curriculum projects since 1956. Total expenditures rose rapidly after the Sputnik year to a peak of about \$10 million in the mid-1960s and then began to decline. In the aggregate, NSF invested approximately \$100 million in development over a period of 18 years.

As shown in Fig. 1.3, NSF has also spent about \$640 million since 1953 for teacher institutes and other teacher training activities. Eighty-three percent of these funds, or \$532 million, has been for traditional institutes and other training activities to provide opportunities for teachers to increase their knowledge of the scientific disciplines without regard for any specific NSF curricula. The remaining 17 percent, or \$110 million, has been spent on teacher institutes and other training projects intended for the implementation of specific NSF-developed curricula. These projects cover subject matter but are mainly limited to what is included in the new curricula. In addition, these projects focused on the teaching methods incorporated in the new curricula and techniques for classroom implementation. Nearly all of these curriculum-specific implementation projects have been supported in 1965.

### NSF Strategy

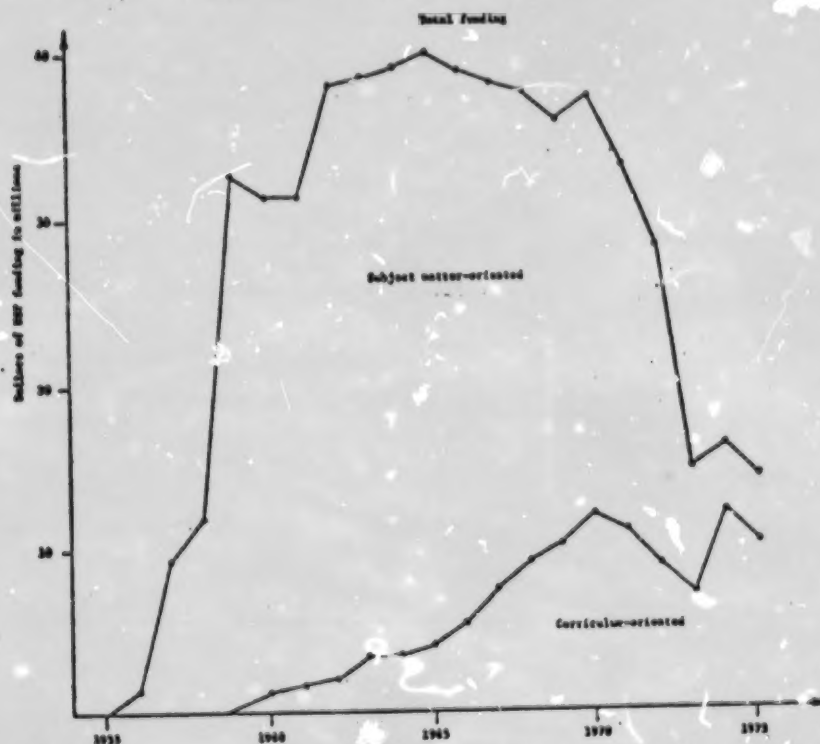
NSF's unique approach was shaped by several institutional and social factors: the social climate of educational concerns in the post-war period; NSF's mission in its early stage of development was to be the leading federal science agency, and the pathbreaking nature of the educational improvement effort; and the inclinations of the initial program leaders. The approach was a set of assumptions shared by the staff.

First, the general goal was to improve the *quality* of science education. Programs designed to train teachers or to influence vocational choices were rejected because they were outside of NSF goals. It was thought that high quality science education would affect both students choosing scientific careers and those who did not. They would be more cognizant as citizens of science and technology's role in society.



SOURCE: Internal NSF study.

Fig. 1.2 - NSF annual expenditures for curriculum development



SOURCE: U.S. House of Representatives, "The National Science Foundations and Pre-College Science Education: 1950-1975," Subcommittee on Science, Research, and Technology of the Committee on Science and Technology, 94th Congress, 2nd Session, January 1976, Appendix A, and an internal NSF report.

Fig. 1.3 - NSF funding of inservice teacher training activities

Second, funds were directed to intermediate points of entry in the education system. Since little was known about which entry points were optimal for intervention, NSF decided to experiment. Many different points were envisioned such as the college curricula, pre-service teacher education, inservice teacher education, and elementary and secondary materials development. The key question was which one would produce the most significant and longest lasting changes at the lowest cost.

Materials development seemed to fit this stringent criteria as textbook writers, publishers, and schools were able to emulate NSF prototypes. NSF was careful in formulating the copyright and royalty policies to market the nationally developed materials while at the same time avoiding windfall gains to individuals and organizations.

Third, the curriculum development projects directly involved scientists in materials development, teacher training, and teacher certification. It was thought that the prestige of the scientists would provide the impetus for change. Besides the NSF institutional charter did not provide the authority to work through state departments of education. Therefore, its policy was to use existing institutions to influence the school curriculum rather than to build new institutions.

#### CRITICISMS OF NSF CURRICULA

Educators, the public, and certainly, the curriculum reformers were initially excited about the promise that the national curriculum projects and the NSF program seemed to hold for improving education.\* The textbooks from the School Mathematics Study Group (which became known as the "New Math") swept into the schools and almost completely replaced older materials.\*\*

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\* Lawrence A. Cremin, *The Genius of American Education*, University of Pittsburgh Press, Pittsburgh, 1965, p. 53; and Robert W. Heath, ed., *New Curricula*, Harper and Row, New York, 1964.

\*\* Richard O. Carlson, "School Superintendents and the Adoption of Modern Math: A Social Structure Profile," in Matthew Miles, *Innovation in Education*, Teachers College Press, New York, 1964, pp. 329-341.



However, by the mid-1960s, the nation's crisis over scientific and technological incapacity had begun to fade and new social currents were rising to the surface. The federal courts began to enforce the 1954 Supreme Court school desegregation decision, causing violent confrontations that brought the educational plight of blacks clearly into public view. Racial demonstrations and civil rights marches in the South culminated in the Civil Rights Act of 1964. Full federal authority reinforced the Supreme Court's desegregation decision by outlawing discrimination in all federally aided programs.

These factors influenced the passage of the Elementary and Secondary Education Act (ESEA) in 1965.\* ESEA Title I was the first national educational policy directed toward the economically disadvantaged. The act stated that the economically disadvantaged were entitled to learning opportunities equal to those enjoyed by the affluent. Following this precedent Congress has in recent years passed legislation to meet the needs of the handicapped and non-English speaking students. Jerome Bruner, the intellectual spokesman of the curriculum reformers (whose book, *The Process of Education*,\*\* became their treatise) was moved to conclude that "...the first order today...(is) redressing the deep, deep wounds that we inflict on the poor, the outcast, those who somehow do not fit within our caste system--be they black or disposed in any way...." He continued: "...the concern (is) no longer to change the schools from within by curriculum, but to refit them altogether to the needs of society, to change them as institutions."

In sharp contrast to NSF strategy, ESEA Title III funds went directly to local school districts for locally initiated projects. The premise was that educational innovation is a local process--blocked only by lack of financial resources. Attention shifted to the local district's *capacity for innovation* rather than the power of the innovation. Much of this attention was directed to *packaging* successful

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\* Title I directed federal funds (\$600 million in the first year, increasing to \$1.5 billion by 1970) through state agencies to local school districts in proportion to their populations of economically disadvantaged.

\*\* Jerome S. Bruner, *The Process of Education*, Harvard University Press, Cambridge, 1960.

projects in order to interest other school districts. The intention was to build an interstate structure for supporting local school district development and dissemination.

One impetus for squelching national development came from Coleman's work documented in *Equality of Educational Opportunity* and numerous evaluations of federally funded projects showing no significant differences in student achievement. It appeared that dollars alone did not affect student achievement.

#### LOCAL SCHOOL DISTRICT PERSPECTIVE

Some school districts benefited greatly from national development. McKinney and Westbury described the curriculum changes produced in several selected school districts by NSF's national development.\* Their findings suggest that national development had a broader impact than student achievement evaluations suggest. One such school district's case study will be summarized.

Prior to 1956, the high school science curriculum in this school district had not changed for many years. One textbook was used for 15 years.\*\* Only two schools had laboratories and advanced courses were not available. A curriculum committee compiled a curriculum guide recommending advanced courses. Content was specified by listing chapter topics from leading textbooks.\*\*\*

No change occurred until 1960 when one science teacher attended an NSF summer institute on PSSC and spread enthusiasm about it. Soon PSSC materials were used in all the science classrooms in the district. Similar patterns occurred with subjects like chemistry and biology. Science was taught as a process of enquiry in newly built laboratories.

Several important phenomena concerning national development are illustrated in this case study. First, the school district had little

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\* W. Lynn McKinney and Ian Westbury, "Stability and Change: The Public Schools of Gary, Indiana, 1940-1970," in *Case Studies in Curriculum Change*, William A. Reid and Decker F. Walker, eds., Routledge and Kegan Paul, London, 1975, pp. 1-53.

\*\* Ibid., p. 24.

\*\*\* Ibid., p. 26.

capability to undertake developmental change on its own. Second, when change occurred, the initiative was local but it was still dependent on national resources for implementation. After the science staff learned about NSF materials in the teacher institutes, they went to the school district for money for new courses and laboratories. The NSF materials and institutes provided teachers with the support to ask for structural changes. This case study illustrates how national development can simultaneously have many objectives and produce many different kinds of effects.

#### Purpose of This Study

As we have discussed the momentum for national development declined in the late 60s. However, interest in whether or not the federal government should support national development became an issue again in the late 70s.

Congressman Conlan charged NSF in 1975 with using financial resources of the federal government to impose threatening and repugnant courses like Man, a Course of Study, on local school districts.\* NSF was plunged into deep controversy over the issue. After reviews were conducted, Congress terminated all funding for the completion of specific curricula.\*\*

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\* U.S. House of Representatives, *Congressional Record-House*, April 9, 1975, H.2585.

\*\* U.S. House of Representatives, Committee on Science and Technology, "National Science Foundation Curriculum Development and Implementation for Pre-college Science Education," 94th Congress, 1st Session, November, 1975; General Accounting Office, "Administration of the Science Education Project: Man, a Course of Study," MWD-76-26, October 14, 1975; National Science Foundation, "Pre-college Science Curriculum Activities of the National Science Foundation," Report of the Science Curriculum Review Team, Vols. I and II, May 1975; U.S. House of Representatives, Subcommittee on Science, Research, and Technology of the Committee on Science and Technology, "The National Science Foundation and Pre-college Science Education 1950-1975," 94th Congress, 2nd Session, Science Policy Research Division of the Congressional Research Service, Washington, D.C., 1975.

In 1976, the National Institute of Education's Curriculum Development Task Force reviewed the national development issue in order to make recommendations to the National Council of Educational Research. The Task Force found great differences of opinion regarding the success of past curriculum reform efforts and the needs for future national curriculum development.

This lack of consensus was attributed to basic value differences and the scarcity of information on past curriculum efforts. Therefore the task force policy recommendations included: (1) flexibility in deciding whether national curriculum development was the best way to respond to an educational problem or opportunity, (2) support only for development that is not being or will not be undertaken by commercial textbook publishers or other agencies in the education system, and (3) requirements that federally supported development not proceed beyond the production of a few exemplary instructional units before determining their need and effectiveness.

Thus, the purpose of this study is to identify the *appropriate role for national development in the improvement of education*. The key words are *development*, as opposed to experiment, demonstration, or other modes of innovative activity; and *national*, as opposed to private, state or local.

A second important issue, which follows from the first, is the selection of *preferred policies in supporting national development*. Are there policies that produce greater effects on education than others? Two distinct strategies will be examined. One is a *programmatic* strategy mainly in response to crises emphasizing curriculum designs for intact incorporation into the school curriculum. These designs would include strategies for incorporation of finished curriculum materials.

In contrast, the second strategy is resources-oriented and provides ongoing development. It emphasizes unfinished materials and building a capacity for curriculum development in intermediate institutions as well as the schools.

Analysis of these two issues--the appropriate federal role in supporting national development and preferred support policies--



requires more definition of different kinds of developmental needs, identification of policy alternatives available to the federal government, and assessment of existing developmental change capabilities in education.

This analysis will be accomplished by assessing the way *inter-institutional relationships* in the educational system often limits an institution's developmental capacity. Selected NSF projects will be analyzed to assess the effectiveness of national development. Classroom evaluations and institutional data (interviews, records) will be our data base. We will be looking for changes in institutions that increase their capacity for development.

#### Study Methodology

The complexity of this conceptual framework and the large number of NSF projects requires that we must be selective:

1. Limit curriculum project analysis to natural science--emphasizing elementary science and secondary biology.
2. Limit institutional analysis to publishers, state adoption boards, and schools.

Limited project resources required use of available research and data. These analyses required different data methodologies. Methodologies will be presented with each analysis.

## II. THE NATIONAL CURRICULUM PROJECTS AND THEIR EFFECT ON THE CLASSROOM

This chapter describes three representative NSF curriculum projects, and summarizes the existing evidence regarding their classroom effectiveness.

The first group of NSF projects originated in the late 1950s and will be represented by the high school project, the *Biological Science Curriculum Study* (BSCS). The second group originated in the early 1960s and will be represented by the *Elementary Science Study* (ESS). Finally, a third group originated in the mid-1960s and will be represented by *Technology and the Man-Made World* (TMMW).

Program selection was based on the following criteria. Each program had to have:

- One project at each grade level;
- A starting date within one of three time periods;
- A minimum of one innovation in each of the components of the school curriculum.

Each of these programs will be discussed in terms of its rationale and key development notions. Information was obtained from interviews with project staff and literature.

### BIOLOGICAL SCIENCES CURRICULUM STUDY (BSCS)

The BSCS project was formed by biological scientists reacting to the intense educational reform climate of the 50s. They thought that biology courses were too fact-oriented, fragmented, and most important--outdated. These scientists wanted to make biology a stimulus to students' innate curiosity about living things and convey the human side of scientific endeavor.\* BSCS advanced four main ideas for improving high school biology.

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\* Bentley Glass, "A New High School Biology Program," *American Scientist*, Vol. 49, 1961, p. 525, and Paul deHart Hurd, *New Directions in Secondary School Science*, Rand McNally, Chicago, 1969, p. 27.

First, the subject matter was outdated. Existing courses over-emphasized the organ-tissue levels of biological organization. They did not include recent scientific advances in the molecular, cellular, population, community, and world biome levels of organization. Nor did they include appropriate scientific treatment of controversial subjects like sex and reproduction in the human species, population control, or organ evolution. Specifically, the scientist broadened the content of the high school biology curriculum.

Second, the subject matter was poorly organized. Therefore the developers organized the subject matter around a few conceptual themes derived from the theoretical structure of biology. The themes were:\*

- Change of living things through time: evolution
  - diversity and unity in the pattern of living things
  - genetic continuity of life
- Complementarity of organism and environment
  - biological roots of behavior
- Complementarity of structure and function
- Regulation and homeostasis: preservation of life in the face of change

They thought that restructuring content would shift learning from mastering facts to a higher conceptual level. Students would be better able to understand science and its relationship to society.

Third, the subject matter presentation *did not* advance a "narrative of inquiry."\*\* Subject matter needed to be reorganized to demonstrate the complex relationship between theory and facts. Text materials needed to present:

...the conclusions of science in the framework of the way they arose and were tested. This (involves telling the students) about the problems posed and the experiments performed

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\* Joseph J. Schwab, *Biology Teacher's Handbook*, John Wiley and Sons, New York, 1964, p. 31.

\*\* Ibid., p. 40.

to indicate the data thus found, and to follow the interpretation by which these data were converted into scientific knowledge.\*

The method raised the "doubts and incompleteness of science and indicates the possibility that through the advance of enquiry, scientific knowledge can change."\*\*

The enquiry approach has implications for teaching. Classroom questions were framed to evoke alternative and defensible answers. The aim was not to win the argument with the "right answer" but rather to find the most defensible solution. This approach could be transferred to non-scientific areas.

Finally, subject matter was too conclusion-oriented. BSCS incorporated laboratory demonstrations of problem situations into the curriculum. Instead of students collecting tree leaves and dissecting frogs, genuine laboratory experiments were conducted. Thus, school laboratories had to be upgraded to be more like professional laboratories.

#### ELEMENTARY SCIENCE STUDY

In 1960, the American Association for the Advancement of Science conducted regional conferences to assess the needs in elementary science education. The overall conclusion of the conference was that elementary science needed to be improved because "future citizens must be generally cognizant of the nature of science and its role in human existence."\*\*\* Changes in both course materials and classroom instruction were required. Several different curriculum projects were started and five of them were funded by NSF. One such project was the Elementary Science Study (ESS) conducted by Educational Services Incorporated (now the Education Development Center).

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\* Evelyn Klinckman, *Biology Teacher's Handbook*, John Wiley and Sons, New York, 1970, p. 23.

\*\* Ibid.

\*\*\* "Science Teaching in Elementary and Junior High Schools," *Science*, Vol. 133, June 23, 1961, p. 2020.



Leading scientists formed ESS to change the curriculum. Students had been memorizing facts and concepts rather than "participating" in scientific enquiry. However, neither scientists nor teachers could clearly specify what approach elementary science should take. No one seemed to know what would work with this age group.

Therefore, it was suggested that scientists and teachers should work directly with children to develop curriculum materials. These materials would be tested at every stage of development. Information gained from one test would be used to revise the material for further testing. This procedure, often called formative development, proved to be productive.

The goal of ESS was to naturalize and humanize science. Four primary ways for achieving this goal can be identified. First, conventional textbooks were replaced by learning kits containing diverse sensory stimuli. The developers believed that conceptual learning was dependent on previous concrete experience with real things. Second, exploration activities were emphasized. Exploration activities encourage children to touch, observe, construct and probe phenomena without adult direction. The developers tried to duplicate life experiences within the classroom so that children would ask questions leading to their understanding the problem. Asking the right question is central to successful exploration.

Third, materials and activities were drawn from the children's natural environment. The Daytime Astronomy Unit stressed observation and measurement skills as tools for learning about the earth, moon, and sun rotations. Children observed these changes by measuring shadows cast by the sun and the daylight moon.

Fourth, instructional materials had a flexible organization. For example, a unit on the butterfly's life cycle could be followed by a unit about growing seeds or the structure of caterpillar eggs. The role of the teacher, then, was to encourage students pursuing their own interests. ESS also enabled teachers to assemble their own materials to fit students' needs, thus providing the structure for an open, flexible curriculum.

### TECHNOLOGY AND THE MAN-MADE WORLD (TMMW)

By the mid-1960s, the problem of an outdated science curriculum was overtaken by the problem of falling enrollments in physics and chemistry. Many felt that coursework in science should be related to the role of science and technology in society so that non-scientific students would become interested in the science projects like Technology and the Man-Made World (TMMW). The goal of TMMW was to help students understand the potential for science and technology in solving society's problems.

There are four main ideas in TMMW. First, the intent of the course was not to teach subject matter content but rather to form attitudes about technology. Second, the course was taught by employing examples of technology in social settings. Concepts were taught by extracting subject matter from familiar examples. As a result, the subject matter content is not organized systematically. Third, the concepts are from engineering and not science. These concepts include decisionmaking and optimization (i.e., making tradeoffs), modeling, systems, feedback, stability, and machine computation. Finally, many laboratory activities are organized around a computer.

### THEMATIC STRUCTURE OF THE SCIENCE CURRICULUM PROJECTS

Common themes run through the science curriculum projects and are summarized in this section. These themes were not new to education. On the contrary these ideas for curriculum change had been advanced by education theorists, philosophers, and blue-ribbon commissions in years past. What clearly distinguished the projects is that ideas for change were translated into tangible materials for classroom use.

#### High School Biology

Hurd reviewed the history of high school biology education since 1890 and found that the recommendations of national curriculum committees for improving the school curriculum have been consistently similar to the ideas advanced in the BSCS\* and other curriculum

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\* Paul deHart Hurd, *Biology Education in American Secondary Schools*, Institute of Biological Sciences, Washington, D.C., 1961.

projects. A sample of Hurd's findings are sufficient to demonstrate his conclusion:

1890-1900 -- Biology should be taught as a laboratory science; Teaching should be shifted from emphasizing biological facts to the principles, ideas, and interrelationships of the discipline;

1900-1910 -- More emphasis should be placed on the "scientific method"; biology should be organized to capitalize on student interest and experience;

1930-1940 -- Science is best learned as an association of facts culminating in a concept expressed as a principal or generalization of science;

No distinction should be made between classes and laboratories as both should be places where problems are solved.

Let us examine some of the common themes of the science curriculum projects in terms of their educational significance.

#### Concrete Manipulation of the Environment: Non-Text Materials

Students should have more opportunities for concrete manipulations of the natural environment. Sidney Strauss said that "concrete operational virtuosity" must be acquired before transition to the level of formal reasoning can be achieved, and that opportunities to achieve such knowledge are severely lacking in the school curriculum.\* Concrete manipulation is important for both learning abstract concepts and acquiring thinking skills. Developers attached great importance to improving cognitive skills.

Students benefited as they gained analytical skills by manipulating and controlling non-text materials. However, manipulating materials required students to have more classroom freedom than ever before. Consequently, the teacher/student relationship changed. Teachers no longer totally controlled the learning experience. Students could now participate. Teaching strategies evolved to fit this new relationship.

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\* Sidney Strauss, *Learning Theories of Gagne and Piaget: Implications for Curriculum Development*, Teachers College Record, Vol. 74, No. 1, September 1972.

### Presentation of Subject Matter in a Meaningful Context

Interpretations of what is "meaningful" to students vary widely among the projects. Materials were designed to build on previous educational experiences and personal interests. BSCS subject matter was organized according to unifying scientific concepts. The topic "organic evolution" was presented in the context of "adaptation to the environment." However, the ESS was organized around "natural experiences." Elementary students studied the topic *motions of the earth* by measuring shadows cast by the sun.

The importance of these curriculum reforms was their *intention* to convert complex scientific knowledge into a form that would be *more useful* to students. To achieve this aim, subject matter was reorganized in a variety of ways, often giving students increased opportunity for choosing subject matter. These ideas were not new but the national curriculum projects translated them into materials for classroom use.

### EVIDENCE OF CLASSROOM EFFECTIVENESS

Whether or not these curriculum changes affected students' learning will be examined in this section. Many of the available evaluation studies have problems. First, the research designs do not often account for intervening variables; and second, variables and outcome measures are not always closely matched to treatments.

### Walker and Schaffarzick Review Curriculum Evaluation Studies

Walker and Schaffarzick<sup>\*</sup> were able to find only 23 studies meeting their criteria of both a *control group* and an *objective test*. Typically, the control groups received a traditional textbook while the experimental groups received the innovative curriculum materials being tested.

However, it is unlikely that any of the studies controlled for treatment implementation. Furthermore, none of these studies had random assignment of curricula to teachers, and only two had random

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<sup>\*</sup>Decker F. Walker and Jon Schaffarzick, "Comparing Curricula," *Review of Educational Research*, Vol. 44, No. 1, Winter 1974, pp. 83-111.



assignment of students. But, in approximately one-half of these studies, some statistical procedure was used to compensate for initial differences in academic ability.

The review included evaluations of more than just NSF science projects. Ten of the 23 studies were from early NSF high school science curricula, five from the School Mathematics Study Group (SMSG) and eight were innovative English and social studies curricula.\* Thus, all of these studies contained innovative curricula.

Results. The innovative curricula, in general, did achieve their objectives. Table 2.1 summarizes the tested comparisons. The experimental groups scored higher than the control groups on almost every tested comparison where the test favored the innovative curriculum, while the controls scored higher in testing comparisons when the tests favored the traditional curricula.\*\* The authors summarized only studies having two criterion tests, one favoring the innovative curriculum and one favoring the traditional curriculum.

Nine studies satisfied this criterion, but as shown in Table 2.2 the results are not much different from Table 2.1. It is difficult to determine whether these results in Tables 2.1 and 2.2 reflect primarily the differences in subject matter or the acquisition of higher order cognitive skills. The tests favoring the innovative curricula tended to emphasize reasoning skills more than the tests favoring traditional programs.

The data demonstrated that the innovative curricula facilitate learning innovative objectives, but do not facilitate traditional objectives.

#### Additional Evaluation Studies

The Walker-Schaffarzick review contains no studies of *activity-oriented* elementary science programs. However, the only other

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\* At least two of the three social studies curricula evaluated were inquiry oriented, similarly to the early high school science projects.

\*\* All the tested comparisons were significant at least at the .05 level of significance using either a "t" or an "F" test.

Table 2.1

SYNTHESIS OF ALL RESEARCH STUDIES REVIEWED  
(Number of Tested Outcomes)

|                                                               | <u>Innovative<br/>More Effective<br/>than Traditional</u> | <u>Innovative<br/>Less Effective<br/>than Traditional</u> | <u>Innovative<br/>Equally Effective<br/>to Traditional</u> | <u>Total</u> |
|---------------------------------------------------------------|-----------------------------------------------------------|-----------------------------------------------------------|------------------------------------------------------------|--------------|
| Test used<br>favored the<br>innovative<br>curriculum          | 44                                                        | 1                                                         | 7                                                          | 52           |
| Test used<br>favored the<br>traditional<br>curriculum         | 5                                                         | 9                                                         | 16                                                         | 30           |
| Not possible<br>to determine<br>which curri-<br>culum favored | 4                                                         | 3                                                         | 9                                                          | 16           |
| TOTALS                                                        | 53                                                        | 13                                                        | 32                                                         | 98           |

\* SOURCE: Decker F. Walker and Jon Schaffarzick, "Comparing Curricula," *Review of Educational Research*, Vol. 44, No. 1, Winter 1974, p. 92.

review--by Rowe--of NSF elementary science programs suggests substantial effects.\* NSF's programs produced statistically significant effects on the acquisition of problem-solving skills, some Piagetian concrete operations, IQ scores, reading-readiness skills, verbal fluency, and language complexity. Furthermore, studies comparing achievement by socioeconomic groups demonstrate that disadvantaged groups do not differ from the advantaged in scientific skill acquisition but they do gain more language and reading skills.

The data were not sufficient to draw firm conclusions on the role of materials. Since teachers were not randomly assigned to the innovative curricula it is difficult to interpret the strong and consistent differences between traditional and innovative curricula. However, materials should not be ignored as an important factor in the educational change process as they can facilitate classroom change.

\* Mary Budd Rowe, "Help is Denied to Those in Need," *Science and Children*, March 1975, pp. 23-25.

Table 2.2

SYNTHESIS OF ONLY RESEARCH STUDIES CONTAINING AT LEAST  
ONE TEST FAVORING EACH CURRICULUM  
(Number of Tested Outcomes)

|                                                       | <u>Innovative<br/>More Effective<br/>than Traditional</u> | <u>Innovative<br/>Less Effective<br/>than Traditional</u> | <u>Innovative<br/>Equally Effective<br/>to Traditional</u> | <u>Total</u> |
|-------------------------------------------------------|-----------------------------------------------------------|-----------------------------------------------------------|------------------------------------------------------------|--------------|
| Test used<br>favored the<br>innovative<br>curriculum  | 28                                                        | 1                                                         | 2                                                          | 31           |
| Test used<br>favored the<br>traditional<br>curriculum | 3                                                         | 8                                                         | 10                                                         | 21           |
| TOTALS                                                | 31                                                        | 9                                                         | 12                                                         | 52           |

\*SOURCE: \* Ibid., p. 93.

#### Instructional Materials Influence Classroom Changes

Another way to measure the effects of instructional materials is to compare subject matter changes in curriculum material *with* what subject matter is covered in the classroom. Changes in the curricula are correlated with student recall. If teachers deviate from the curriculum materials then curriculum changes would not be highly correlated with student recall.

A survey of 2500 high school seniors asked whether they had studied certain biology topics.\* Some of these students had used *Modern Biology*, the standard text for the high school level, and the rest one of the three BSCS versions (Blue, Green, and Yellow).\*\* These four textbooks place substantially different emphasis on the topics of DNA, biological imprinting, and mitosis.

\*William Kastrinos, "A Survey of Teaching Practices in Biology in Secondary Schools," TDR-69-6, Educational Testing Service, May 1969.

\*\*Students who had taken more than one biology course were eliminated from the survey.

The results were that student recall of topics is highly correlated with the distribution of topic emphasis in their textbook. Students normally take biology in the tenth grade; thus, these results were obtained two years after the topics were studied. The high correlation of student recall of topics studied and emphasis in the BSCS texts had an influence on what subject matter topics the teachers covered in their biology classes.

One study describing individualized reading indicates how complex the interactions were between materials and teacher behavior. The question asked was whether or not increasing the number of materials in the classroom results in a higher level of individualization. Variables included: the degree of individualized reading, the extent of instructional grouping, and the number of different materials.

The result was that the number of different materials used is highly correlated with the extent to which students are grouped. Table 2.3 points out that classrooms using all of the same materials tend to have whole-class instruction, while those where students were grouped for instruction tend to use a number of different materials. However, causality cannot be concluded.

Data exists from another analysis supporting number of different materials as a causal factor for higher order teacher behavior. Grouping and number of materials variables were correlated with the two selected measures for extent of individualization. One measure called "breadth" of teachers decisionmaking base\* was significantly correlated ( $r = .18$ ,  $p = .01$ ) with the variety of materials used but not the grouping strategy employed.

A second measure for individualization was the extent to which teachers evaluated effectiveness of their teaching approach and changed their approach over time. More grouping was negatively correlated with the variable ( $r = .15$ ,  $p = .01$ ) while number of materials had almost no correlation ( $r = .04$ , not significant at  $p = .10$ ).

These negative correlations can be interpreted as indicating that teachers having extensive grouping and large numbers of materials

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\* A measure containing a 20-item scale of indicators such as amount of discussion with students of progress and work, the use of plans, and the use of outside professional channels.



Table 2.3

RELATIONSHIP OF CLASSROOM GROUPING PATTERN AND  
MATERIALS VARIETY IN ELEMENTARY READING  
(Number of Classrooms)

| Most frequent grouping pattern employed | All students use the same materials | Two-to-three groups with different materials | Four or more groups with different materials | Each student has different materials |
|-----------------------------------------|-------------------------------------|----------------------------------------------|----------------------------------------------|--------------------------------------|
| Whole class                             | 11                                  | 0                                            | 0                                            | 0                                    |
| Two-three groups                        | 7                                   | 41                                           | 1                                            | 0                                    |
| Four or more groups                     | 2                                   | 13                                           | 58                                           | 0                                    |
| Students work individually              | 5                                   | 9                                            | 14                                           | 47                                   |

SOURCE: Joann K. Intilli and James E. Flood, "The Effect of Selected Student Characteristics on Differentiation of Instruction in Reading: The Meaning and Correlates of Individualization," Stanford Center for Research and Development on Teaching, unpublished report, 1976. The data shown were obtained from a questionnaire returned by 208 California teachers.

in their classrooms are more satisfied with their teaching; or the complexity of their environment is so taxing that they do not choose to evaluate their teaching effectiveness.

The overall conclusion is that *number of materials* is strongly associated with a high degree of *individualized instruction*. In a broader context, it is possible that as available materials increase and diversify, teachers will be more inclined to individualize. However, publishers are sensitive to their market. If the school would use diverse materials the publishers would be making them available. Publishers keep their innovative activity in equilibrium with the school curriculum.

The national curriculum projects displaced this equilibrium, as we shall see in the subsequent chapters, by giving publishers new ideas and by challenging the institutional barriers to innovations. The critical question is whether the effects of the projects are limited by the extent of curriculum materials' usage or are there larger, more permanent institutional effects?

### III. INSTITUTIONAL FACTORS FAVORING MAINTENANCE OF THE EXISTING CURRICULUM

This chapter identifies institutional factors favoring maintenance of the school curriculum. The three institutions to be analyzed are the publishing industry, state adoption boards, and local school districts. The relationships among them strongly affect the school curriculum. State adoption boards and school districts often limit the incorporation of national curriculum projects. As a consequence, publishers refused to develop curricula unacceptable to state boards and school districts. How these factors influenced publisher's decisions about new products will be examined.

#### METHODOLOGY FOR IDENTIFYING INSTITUTIONAL FACTORS

We interviewed publishers, state adoption board administrators, and national curriculum project personnel to find out *how* these three institutions affected the selection and implementation of new products, particularly in science.

The criteria for publishers interviewed were:

- (1) those who had not marketed any of the NSF curricula or two or more of them; and
- (2) those who had entered the science market within the last ten years or more than ten years ago.

These criteria formed a two-by-two cell matrix with one publishing company per cell receiving a semi-structured interview. One researcher interviewed each publishing company, including the general manager and members of the sales and editorial staff. Pilot interviews were conducted with three other publishers--making a total of seven publishers interviewed.

Members of state adoption boards received a semi-structured interview by telephone. Site visits were made to the California and Florida state boards.

### NEW PRODUCT DEVELOPMENT IN PUBLISHING

Publishers point out two important issues favoring maintenance of the existing school curriculum. They include: (1) limited funds available for product investment; and (2) strong incentives to develop programs *acceptable* to the majority of teachers.

#### Levels of Investment

Publishers' new product development budgets are largely determined by the industry cost structure. Table 3.1 shows cost structure breakdown and the revenues earned by different sized firms. Publishers typically invest ten percent of their revenues in new products. They pay 35 percent for product manufacturing (including the costs of making plates, printing, and binding), eight percent for distribution, 20 percent for marketing and sales, 12 percent for overhead and six percent to stockholders as profits. Annual product investment ranges from \$5.3 million for large firms to \$400,000 for small firms. Sixty percent of these funds are spent on royalty payments to authors, 30 percent for editorial staff and consultants, and ten percent for production (layout, photography, artwork, and copyediting). Publishers' investment in new products across all subjects is roughly \$50 million.\*

The industry might be able to increase product investment if it could reduce production costs and/or schools could spend more on curriculum materials. Manufacturing and distribution costs are largely fixed by technology and content standards of the industry. Furthermore, schools are currently spending less than one percent of their budgets on materials.

Level Within Subject Area. The \$50 million investment in new products is highly fragmented. The amount that can be spent on new product development in a subject area is about ten percent of its revenues. Some *estimates* of the amounts *leading publishers* can invest

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\* Because this figure of \$50 million is based on data from only 29 of the largest publishers, the actual figure is somewhat higher. But the error is not great because the report from which this figure was obtained estimates total industry revenues to be about \$800 million as compared to the total of \$5 million.

Table 3.1.  
COST STRUCTURE OF EL-HI PUBLISHING FIRMS, 1975  
(Dollars in Millions)

| Size range (net sales) | Average<br>Smaller Firm |                  | Average<br>Medium-Sized Firm |                  | Average<br>Large Firm |                  | Industry Total |         |
|------------------------|-------------------------|------------------|------------------------------|------------------|-----------------------|------------------|----------------|---------|
|                        | Up to \$8 million       |                  | Between \$8 and \$25 million |                  | Over \$25 million     |                  |                |         |
| Number of Firms        | 11                      |                  | 11                           |                  | 7                     |                  |                |         |
|                        | Dollars                 | Percent of Sales | Dollars                      | Percent of Sales | Dollars               | Percent of Sales | Dollars        | Percent |
| <b>Revenues:</b>       | 3.6                     | 100              | 15.3                         | 100              | 44.9                  | 100              | 527.35         | 100     |
| From sales (net)       | (3.5)                   | (97)             | (15.0)                       | (98)             | (44.2)                | (98)             | (513.95)       | (99)    |
| From other sources     | (.1)                    | (3)              | (.3)                         | (2)              | (.7)                  | (2)              | (3.40)         | (1)     |
| <b>Costs:</b>          |                         |                  |                              |                  |                       |                  |                |         |
| Product Development    | .39                     | 12               | 1.65                         | 11               | 5.34                  | 12               | 50.13          | 11      |
| Royalties              | (.21)                   | (7)              | (.89)                        | (6)              | (2.62)                | (16)             | (30.70)        | (16)    |
| Editorial              | (.13)                   | (4)              | (.55)                        | (4)              | (2.17)                | (5)              | (22.75)        | (4)     |
| Production             | (.05)                   | (1)              | (.21)                        | (1)              | (.55)                 | (1)              | (6.68)         | (1)     |
| Manufacturing          | 1.24                    | 35               | 5.96                         | 39               | 14.4                  | 33               | 179.77         | 35      |
| Plant costs            | (.14)                   | (4)              | (1.00)                       | (7)              | (2.50)                | (6)              | (30.08)        | (6)     |
| Paper, printing, etc.  | (1.1)                   | (31)             | (4.96)                       | (33)             | (11.9)                | (27)             | (149.69)       | (29)    |
| Distribution           | .27                     | 8                | 1.56                         | 10               | 3.45                  | 8                | 39.83          | 88      |
| Marketing              | .87                     | 25               | 3.66                         | 24               | 8.39                  | 19               | 108.61         | 21      |
| Administration         | .48                     | 13               | 1.91                         | 12               | 5.49                  | 12               | 64.65          | 13      |
| <b>Net income:</b>     |                         |                  |                              |                  |                       |                  |                |         |
| After taxes (profit)   |                         |                  |                              |                  |                       |                  |                |         |
| Before taxes           | .21                     | 6                | .67                          | 5                | 7.54                  | 17               | 62.50          | 12      |
| Taxes                  | .08                     | (2)              | (.42)                        | (3)              | (3.81)                | (9)              | (32.31)        | (6)     |
| Profit                 | .13                     | (4)              | (.25)                        | (2)              | (3.72)                | (8)              | (30.19)        | (6)     |

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SOURCE: "Industry Statistics, 1975," Association of American Publishers, New York, 1976, Table F8. These data are for 29 of the largest firms belonging to the AAP.



in new products range from several million dollars in elementary reading and mathematics to a few hundred thousand dollars in secondary science (Table 3.2). However, the elementary curricula data are combined for grades K-6 so that the amounts per grade level in reading and mathematics are also about a few hundred thousand dollars. Thus, market and cost structure yields on the average about several hundred thousand dollars per grade level for product development over a five-year period.

Cost of Development. The NSF curriculum projects costs for the elementary science programs were \$600,000 per grade level and for early high school science projects a few million dollars per grade level. These figures are much higher than publisher's normal investment capabilities.

One major publisher in the late 1940s developed a "new mathematics" curriculum similar to SMSG. He spent \$10 million over a 20-year period and nearly failed. The mathematics department editor of this publishing firm said, "What saved our lives was World War II, nuclear energy, automation, Sputnik, and the School Mathematics Study Group..."\* As shown in Table 3.3, SMSG spent 40 percent more than this publisher but for programs spanning all the grade levels from kindergarten through twelfth grade. SMSG's cost was approximately the same as this publisher's for grades K-8.

NSF development costs are high due to classroom trials for testing and revising curriculum materials. Testing materials in this way eliminates some of the risks of innovation. Publishers without sufficient funds for this kind of development incur great risks.

#### Effects of Curriculum Regularities

Innovative programs can *reduce* a publisher's share of the market. The more irregularity in a program, the more likely this is to happen. The BSCS Yellow Version was not very different from traditional texts. This version had twice the sales of the more innovative Blue and Green Versions of the same program.

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\* Hillel Black, *The American School Book*, William Morrow, New York, 1967, p. 71.

Table 3.2

ESTIMATED INVESTMENT OF EL-HI PUBLISHERS IN NEW PRODUCT  
DEVELOPMENT BY SUBJECT AREA, 1975  
(millions)

| Subject Area             | 1975*<br>Revenues | Student**<br>Enrollment | Estimated Annual<br>Investment in<br>New Products<br>by All Firms | Approximate <sup>††</sup><br>Investment<br>in a Subject<br>Area by<br>Leading Firms<br>Over a Pro-<br>duct's Lifetime | Estimated<br>Investment<br>per<br>Grade Level |
|--------------------------|-------------------|-------------------------|-------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------|-----------------------------------------------|
| <u>Elementary (K-6)</u>  |                   |                         |                                                                   |                                                                                                                       |                                               |
| Reading                  | \$135.7           | --                      | \$13.5                                                            | \$4.2                                                                                                                 | .6                                            |
| Mathematics              | 70.0              | --                      | 7.0                                                               | 4.3                                                                                                                   | .6                                            |
| Science                  | 35.1              | --                      | 3.5                                                               | 1.8                                                                                                                   | .3                                            |
| Other                    | 99.1              | --                      | 9.9                                                               | NA                                                                                                                    | NA                                            |
| <u>Secondary (9-12)</u>  |                   |                         |                                                                   |                                                                                                                       |                                               |
| Mathematics:             | 20.8              | 13.2                    | 2.08                                                              |                                                                                                                       |                                               |
| Algebra                  |                   |                         |                                                                   |                                                                                                                       |                                               |
| Elementary               |                   | 1.9                     | .30 <sup>x</sup>                                                  | .75                                                                                                                   | .75                                           |
| Intermediate             |                   | 1.2                     | .19 <sup>x</sup>                                                  | .48                                                                                                                   | .48                                           |
| Advanced                 |                   | 1.4                     | .06 <sup>x</sup>                                                  | .16                                                                                                                   | .16                                           |
| Other                    |                   | 9.7                     | 1.53                                                              | NA                                                                                                                    | NA                                            |
| Science:                 | 19.4              | 12.4                    | 1.9                                                               |                                                                                                                       |                                               |
| Biology, 10th<br>grade   |                   | 2.7                     | .4 <sup>x</sup>                                                   | .3                                                                                                                    | .3                                            |
| Chemistry,<br>11th grade |                   | 1.0                     | .2 <sup>x</sup>                                                   | .2                                                                                                                    | .2                                            |
| Physics, 12th<br>grade   |                   | 1.4                     | .1 <sup>x</sup>                                                   | .1                                                                                                                    | .1                                            |
|                          |                   | 8.3                     | 1.30                                                              | NA                                                                                                                    | NA                                            |
| All other sub-<br>jects  | 115.5             | NA                      | 11.5                                                              | NA                                                                                                                    | NA                                            |
| Total                    | 492.2             | --                      | 49.2                                                              | --                                                                                                                    | --                                            |

SOURCES: \* "Industry Statistics," Association of American Publishers, New York, 1976, Tables F3 and F4. Data are for 23 publishers who reported.

\*\* Logan Osterndorf, "Summary Offerings and Enrollments in Public Secondary Schools, 1972-1973," Department of Health, Education, and Welfare, National Center for Educational Statistics, 1975, Table A.

NOTES: † Annual Investment in new product development by all firms is estimated to be 10 percent of total revenues in a subject area.

†† Total investment by each leading firm in a subject area is estimated to be the annual investment by all firms over five years divided by number of publishers in subject area having a total of over 50 percent of the market. Market shares are shown in Table 6.

<sup>x</sup> Annual investment in subject area is assumed to be proportional to enrollments in a subject area as a proportional of total enrollments in subject.

Table 3.3

DEVELOPMENT COSTS OF SELECTED NSF  
NATIONAL CURRICULUM PROJECTS  
(millions)

| Project Name                                              | Grade Levels | Total Development Cost | Cost per Grade Level |
|-----------------------------------------------------------|--------------|------------------------|----------------------|
| <b>Mathematics</b>                                        |              |                        |                      |
| School Mathematics Study Group                            | K-12         | \$14.4                 | \$1.1                |
| University of Illinois Committee on School Mathematics    | 9-12         | 4.9                    | 1.2                  |
| Minnesota School Math and Science Project                 | K-3          | 5.0                    | 1.2                  |
| <b>Science</b>                                            |              |                        |                      |
| Physical Science Study Committee                          | 12           | 5.3                    | 5.3                  |
| Biological Sciences Curriculum Study                      | 10           | 10.4                   | 3.5                  |
| CHEM Study                                                | 11           | 2.6                    | 2.6                  |
| Technology and the Man-made World                         | 11           | 2.0                    | 2.0                  |
| Time, Space, and Matter                                   | 7-9          | 1.2                    | .6                   |
| Earth Sciences Curriculum Project                         | 7-10         | 3.5                    | 3.5                  |
| Introductory Physical Science                             | 7-9          | .8                     | .8                   |
| Physical Science II                                       | 9-10         | .6                     | .6                   |
| Human Sciences                                            | 7-9          | 1.2*                   | --                   |
| Science Curriculum Improvement Study                      | K-6          | 4.3                    | .6                   |
| Elementary Science Study                                  | K-8          | 7.6                    | .8                   |
| Science - A Process Approach                              | K-6          | 2.3                    | .3                   |
| Unified Science and Mathematics for the Elementary School | K-6          | 2.6*                   | --                   |

SOURCES: U.S. House of Representatives, "The National Science Foundation Curriculum Development and Implementation for Precollege Science Education," Committee on Science and Technology, 94th Congress, 2nd Session, November 1975, pp. 303-308, and internal NSF report.

NOTE: \*Development is not completed for Human Sciences and Unified Science and Mathematics for the Elementary School. Final development costs will be greater than shown.

Market entry is especially difficult when one or two publishers have a major portion of the market. Teachers become "comfortable" with a program and are not willing to try something new. It takes a long time to establish a new program's credibility. Publishers are discouraged from investing in innovative programs which take a long time to return their investment; whereas publishers see a large return from simply upgrading existing programs. Upgrading features appealing to teachers--such as revisions of text materials, teacher's guides, student tests, transparencies, and other aids facilitating classroom use--are perceived as an excellent investment.

Market realities encourage publishers to be cost conscious and pragmatic, thus discouraging innovation.

#### STATE ADOPTION BOARD PRIORITIES

Subject matter priorities of state adoption boards also limit change. (Twenty two out of 49 states have adoption boards.) Prior to the curriculum movement no state board permitted non-text curricula to be approved. However, by 1975 only four states continued with a "Textbook only" policy. When the content of a curriculum is not consistent with a state's priorities, state adoption board approval is hard to get. When this happens publishers face a substantial loss of the elementary market.

Most state adoption boards formally state their priorities in the form of curriculum guidelines that are often used for planning by local school districts. Some states like California have a State Curriculum Commission which prepares "curriculum frameworks." For example, in elementary mathematics seven different content strands were identified, broken into substrands, each having ten to forty different topics for each grade level. Publishers often use the content strands as a guide for course content.

Curricula approvals by state adoption boards are made after staff from the board, the local school districts, and teachers review the programs. Membership on adoption boards includes representatives from education as well as the lay public.



California and Texas heavily influence the publishing industry. Combined, they have the highest share of the market. California has 6.5 percent and Texas has 7.1 percent of the elementary market. Table 3.4 gives an estimated share of the market for each of the 22 adoption states. Winning either the Texas or California adoption can increase sales substantially. Salesmen often play an important intermediary role in the adoption process as they often know *who* is influential and *how* the curriculum is changing. Such information can influence whether or not a state adopts a program.

Adoption states often have similar subject matter priorities as they communicate and exchange guidelines with one another. Since publishers cannot develop different materials for every state, the adoption states influence what kinds of materials non-adoption states are sold. Limits on the number of approvals also limits the selection for everyone, and helps to maintain the existing curriculum.

Adoption regulations in most states are expensive. Publishers are required to supply a sample copy to each member of all review committees. Upon request, samples are distributed to school districts. Furthermore, they are often asked to pilot programs in more than one school. Pilots for a non-text program cost as much as \$5,000 as compared to a few hundred for a textbook pilot program.

#### ADOPTION STATES INFLUENCE NATIONAL CURRICULUM

Changing subject matter in the local school districts is not an easy task. NSF tried to introduce new subject areas as well as new content into traditional areas. In this section, we will look at factors limiting these changes in the school curriculum.

#### New Subject Matter Areas

New subject matter areas include courses containing subject matter that has never been taught, that is taught at a different grade level, and that integrates existing courses.

Table 3.4  
ESTIMATED EL-HI PUBLISHERS' SALES TO STATES  
WITH ADOPTION BOARDS  
(Millions of Dollars)

| Adoption States | Elementary |         | Secondary |         |
|-----------------|------------|---------|-----------|---------|
|                 | Dollars    | Percent | Dollars   | Percent |
| Alabama         | 3.6        | .9      | 3.3       | 1.4     |
| Arizona         | 5.3        | 1.3     | -         | -       |
| Arkansas        | 4.4        | 1.1     | 2.6       | 1.1     |
| California      | 26.8       | 6.5     | -         | -       |
| Florida         | 11.0       | 2.7     | 6.5       | 2.8     |
| Georgia         | 8.2        | 2.0     | 4.6       | 2.0     |
| Idaho           | 1.5        | .4      | .9        | .4      |
| Indiana         | 8.8        | 2.1     | 5.0       | 2.1     |
| Kentucky        | 5.7        | 1.4     | 3.6       | 1.6     |
| Louisiana       | 5.1        | 1.2     | 3.1       | 1.3     |
| Mississippi     | 4.3        | 1.0     | 1.9       | .8      |
| Nevada          | 1.3        | .3      | .6        | .3      |
| New Mexico      | 1.5        | .4      | 1.2       | .5      |
| North Carolina  | 22.0       | 5.4     | 9.2       | 3.9     |
| Oklahoma        | 4.8        | 1.1     | 3.0       | 1.3     |
| Oregon          | 9.9        | 2.4     | 5.2       | 2.2     |
| South Carolina  | 5.5        | 1.3     | 2.9       | 1.3     |
| Tennessee       | 5.2        | 1.3     | 5.0       | 2.2     |
| Texas           | 29.0       | 7.1     | 16.0      | 6.9     |
| Utah            | 2.4        | .6      | 1.3       | .6      |
| Virginia        | 11.4       | 2.8     | 5.4       | 2.3     |
| West Virginia   | 2.0        | .5      | -         | -       |
| TOTAL           | 180.3      | 43.9    | 81.3      | 35.0    |
| ALL STATES      | 411.0      | 100.0   | 232.0     | 100.0   |

SOURCE: "Industry Statistics, 1975," Association of American Publishers, New York, 1976, Table F5b.

Adoption Data. The data in Table 3.5 on textbook sales for selected high school courses\* points out how difficult it is to introduce new subject matter into the school curriculum. The three curricula that fit into the existing school curriculum (HPP\*\*, BSCS, and CHEM Study) were adopted to a far greater extent than curricula (TMMW and BII) which are different. Furthermore, their textbook sales were proportional to total student enrollments in their subject matter areas.

#### Curriculum Factors

At the high school level, the new discipline-oriented structure of high school science departments has been a major difficulty in implementing new subject matter.

One factor is that high school science teachers tend to specialize in one of the three principal science disciplines of biology, chemistry, and physics. As a result, their subject matter expertise is concentrated in their specialty and they identify professionally with it. This specialization encourages teachers to resist innovations that introduce new or reorganized subject matter. Shifts in subject matter placement from one grade level to another results in similar shifts in teachers required for each discipline. Teachers are concerned that lower student enrollment will reduce the number of teaching positions. Physics teachers worried that this would divert potential physics students.

The status hierarchy, especially important in high school science departments, makes physics teachers the school elite. The science department chairman is usually a former physics teacher. Physics is the most difficult subject and usually attracts the scientifically brightest students. As a consequence, physics teachers are reluctant to support curriculum innovation that would jeopardize their coveted positions.

Elementary school science is another matter as it is not discipline-oriented. The average elementary science teacher takes only

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\* The data on textbook sales are only for the first five years after the curriculum was first introduced because textbooks are normally revised shortly after this period.

\*\* HPP is the Harvard Project Physics curriculum.

Table 3.5

UNIT SALES AND IMPLEMENTATION SUPPORT FOR SELECTED NSF SCIENCE CURRICULA  
IN THE FIRST FIVE YEARS OF COMMERCIAL AVAILABILITY

| Curriculum Project            | Commercial Availability | Textbook sales (000 of copies) | NSF Implementation (\$000) | Total students in subject area 1961 (000) |
|-------------------------------|-------------------------|--------------------------------|----------------------------|-------------------------------------------|
| Subject area already existed: |                         |                                |                            |                                           |
| HPP                           | 1968                    | 220                            | 3400                       | 400                                       |
| CHEM Study                    | 1962                    | 560                            | 1730                       | 740                                       |
| BSCS Versions                 | 1963                    | 1700                           | 3900                       | 1800                                      |
| Subject area did not exist:   |                         |                                |                            |                                           |
| TMMW                          | 1969                    | 26                             | 2200                       | -                                         |
| PSSI                          |                         | 32                             | *                          | -                                         |

SOURCES: HPP sales data are from the publishers Holt, Rinehart, and Winston. BSCS sales data are from royalty records supplied by BSCS, Inc. TMMW sales data were supplied by the publisher McGraw Hill. PSSI sales data were supplied by the publisher D.C. Heath. The data on implementation are from an internal NSF study. The overall results of this study are available in U.S. House of Representatives, Committee on Science and Technology, "National Science Foundation Curriculum Development and Implementation for Pre-College Science Education," 94th Congress, First Session, November 1975, pp. 303-308.

NOTE: \* Implementation data for the PSSI curriculum are not readily available.



17 semester-hours of undergraduate science courses (with a standard deviation of 15 semester hours).<sup>\*</sup> However, college course work does not appear to be correlated with innovation usage. Publishers still consider the factors of teacher subject competency, science course placement, and status strong enough to be a barrier to innovation.

Thus, organizational factors characteristic of the publishing industry, adoption boards, and school districts affect their relationship with one another, and in turn serve to maintain the existing curriculum. Until the national curriculum development projects, an innovation like *non-text materials* could not penetrate the system despite general agreement of its educational desirability. In the next section we will look at each of the three institutions in terms of those organizational factors that held back classroom incorporation of non-text materials.

#### INCORPORATION OF NON-TEXT MATERIALS

Curriculum programs containing non-text materials were especially difficult to incorporate into the school curriculum since el-hi publishers were not organized for producing, distributing, and selling them; most state adoption boards approved only textbook programs, and local school districts were not organized to support their classroom use.

#### Publishers

El-hi publishers did not have the capacity for *producing* and *packaging* non-text materials. Long-term relationships with printing firms enabled books to be printed at low costs. No such relationships existed for non-text materials. Suppliers had to be found for the multipart programs containing wooden blocks, seeds, etc. These parts had to be assembled into a kit that would be competitively priced with books. Otherwise, the program would not sell. If manufacturing costs

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<sup>\*</sup>Robert Steiner, et al., "A Survey of Science Teaching in Public Schools of the United States (1971)," Volume 4--Elementary Schools, ERIC Science, Mathematics, and Environmental Education Clearinghouse, Ohio State University, Columbus, Ohio, 1974, Table 8.

for books range from \$1.00 to \$1.50 with an average class size of 30, the cost would be about \$30 to \$45 per classroom to spend on kits.\*

Publishers of non-text materials faced the problems of an unreliable format and costs that could get out of control. Facing these uncertainties, the incentive to stay with standard textbook programs was very strong.

In addition, programs based on enactive materials are difficult to *distribute* to the schools. Textbooks can be easily inventoried, boxed, and shipped. Non-text programs containing manipulatives often have many parts, each of which can be separately ordered. Regular inventories have to be maintained to fulfill replacement requests. Publishers have to respond quickly to replacement orders or risk losing customers because of bad service.

Manipulatives were inconvenient for salesmen to carry when they contacted teachers and administrators in local school districts. Instead of a single suitcase of sample books, salesmen had to lug around large kits and accessory materials. Furthermore, salesmen had to explain programs they often were not trained to understand. Since salesmen earn their money from selling programs, top management increased the incentives for salesmen to sell non-text materials.

The el-hi sales force plays a key role in curriculum dissemination. Forty-two percent of teachers in a science study rated textbook salesmen "most important" as an information source. Only 24 percent of the teachers relied on teaching colleagues, 19 percent on professional journals, 7 percent on science associations, with only 1 percent on state science staff as an information source.\*\*

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\* The approximate cost of a 320-page, cloth-backed book containing about one half-tone picture per page, with 50-pound paper, and printed in a quantity of 20,000 is \$1.20.

\*\* James Michael Grahm, "A Field Initiated Study for the Improvement of Secondary School Science Instruction in Minnesota," MS thesis, Bemidji State College, Bemidji, Minnesota, June 1974. Whether the "importance" of these sources varies by types of curriculum innovation, or whether textbook salesmen are "most important" in the sense of providing only initial awareness of curriculum innovations, or in the sense of convincing them to adopt an innovation, is not clear from this study.

### Adoption Boards

Two major factors limited non-text materials classroom use. The *textbook only policy* and *sampling requirement* of state adoption boards made it appear unlikely for non-text materials to ever be adopted into the curriculum.

Prior to the curriculum movement *no* state adoption board permitted non-text materials to be approved. The policy was either written into law or was an unwritten rule. The policy meant that non-text materials could not be sold in approximately 44 percent of the elementary market and a small proportion of the high school market.

Adoption regulations in most states required publishers to supply a minimum of one copy to each member of all review committees. Furthermore, publishers were often required to pilot programs up for adoption

### School Districts

The *organization* of the school districts did not always support using non-text science curriculum. Since elementary science has traditionally been taught from textbooks, few school districts have enough staff, space, or budget to purchase sufficiently high-quality materials. Non-text programs have items needing periodic replacement and repair, requiring open space, and often costing about twice as much as textbooks. Districts using this curriculum were very likely to have an elementary science coordinator, specialized science teachers, and centralized support for purchasing and other administrative functions. \*\*

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\* A teacher would normally use a few of the 50 units in a given year.

\*\* Dean K. Whitla, "Essentially Elementary Science: A Report on the Status of Elementary Science in Massachusetts," Graduate School of Education, Harvard University, Cambridge, Massachusetts, March, 1973, p. 109. The data in this study are based on a questionnaire survey of 214 local school districts in Massachusetts.

*Classroom interaction patterns* are affected by non-text materials. Students can work individually or in small groups and can choose what to study. As a consequence teachers shifted from traditional group lectures to the function of supporting students working independently. Many teachers found these behavioral changes difficult to make.

Sarason found the traditional mode of teaching to be difficult to change because of organizational factors such as teachers having to cover certain subject matter, because the routines of school life reinforce regularity, and because of the lack of "consultant help" from principals, curriculum supervisors, and workshops, worked against making the change.\* Parents expect schooling to be conducted in a certain way. Section IV will examine just what effects NSF did make.

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\* Seymour B. Sarason, *The Culture of the School and the Problem of Change*, Allyn and Bacon, 1971, pp. 72-78.



#### IV. EFFECTS OF NATIONAL CURRICULUM DEVELOPMENT ON INSTITUTIONS

This chapter assesses the *effects of NSF projects* on key institutions such as publishing, state adoption boards, and local school districts. The question is: In what ways does an institution's organizational structure change to fit a higher level of innovative activity?

##### PUBLISHING

Institutional changes in publishing will be considered by analyzing their level of innovative activity. In publishing, innovative activity is measured in terms of rate of new products as well as amount of time spent on production, development, and integration activities. The desired effect would be to shift time spent from production to development and integration activities.

We will accomplish this evaluation by first looking at the rates of new products introduced. Second, we will tabulate the number of publishers in a subject area as an indication of changes in their share of the market. It is assumed that increasing the number of publishers increases the number that can invest in viable alternative curricula. However, this data is insufficient to conclude how different the new programs are from existing programs. Third, we will describe changes in the kind of innovative activity for the four publishers interviewed.

##### Rates of New Product

The NSF curriculum projects doubled the rates of new science product. These data were obtained by compiling the number of new basal curricula marketed from 1950 to 1975. Basal products were defined as those materials capable of being a complete course.

For example, since the high school science curricula were introduced, the rate of new product development increased in biology, chemistry, and physics. In the tenth grade, biology increased from

1.5 to 3.2 products per year; chemistry, from 1.0 to 5.4; and physics, from 1.8 to 3.8. Science subject areas combined increased from 1.2 to 6.2. However, at the elementary level increases ranged from 1.8 to 2.6 per year.

The dramatic market growth should not be attributed solely to national development for the following reasons: rates of new products corresponds to the introduction of NSF curricula at both the elementary and secondary levels; market growth in life science where there was no national product lags behind physics and earth science, both having a large number of national projects (Table 6.1), furthermore, student enrollment increases were *not more substantial* in the 1960s and 1970s than the 1950s (in recent years we have seen elementary school enrollments actually decrease); lastly, publishers note that parent companies have not been willing to finance major expansions in their el-hi divisions in the 1970s. Nevertheless, in the 1970s product rates increased.

#### Changes in Market Shares

Since increases in the rate of new products parallel the growth in number of publishers, the market shares must have been redistributed. For many years *Modern Biology* had a monopoly over the market. With the introduction of BSCS curriculum student usage of *Modern Biology* fell from approximately 80 percent to about 25 percent of the market. The 10th grade biology market share shows that all BSCS versions have about 20 percent of the market, with 10 percent for the Green Version, six percent for the Yellow Version, and four percent for the Blue Version. \* Available evidence suggests that BSCS changed the situation

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\* These percentages were calculated by extrapolating student enrollments in a straight line from the data point in 1972. Based on some unpublished work, Robert Howe of the Center for Science, Mathematics, and Environmental Education at Ohio State University, estimates that enrollments in high school biology may have fallen slightly in the 1970s which would increase the percentages given in the text.

so that the biology market is about equally divided among *Modern Biology*, the five BSCS curricula, and four other publishers' product.\*

These results support carrying development through the materials production stage. The three publishers of the BSCS materials did not have the money to risk innovative development. If BSCS had only issued guidelines and prototype materials, then publishers may not have been able to invest substantial amounts in developing finished materials.

*Modern Biology* responded to BSCS publishers' success by incorporating much of their innovative material. But by 1970 total sales of *Modern Biology* and the three BSCS curriculum fell in relation to the total market as new curricula became more successful. Two reasons explain this market drop. First, when *Modern Biology* shifted its content away from the old norms, other publishers took advantage of the opening. And second, at the local level there was a greater receptivity to alternative approaches for teaching biology.

Publishers of NSF materials expanded their staff and upgraded their requirements for authors and editorial staff. The publishers of NSF materials increased their visibility in the market place. Neither of the two other non-NSF publishers interviewed grew as much.

#### Capacity for Development

Data on new products and market shares do not tell the whole picture about innovation. To what extent innovation has been institutionalized in an organization still needs assessment.

In-house Initiative. The classical author/editor model was generally followed before national development. Authors were responsible for the content while the in-house staff were responsible for journalistic quality and presentation. However, the role of in-house staff has changed from strictly producing to developing a manuscript. In-house staff now often formulates course objectives, supervises content,

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\* Student usage estimates indicate *trends in usage* and not precise numbers of students figures. Estimates are based on textbook sales data by year and survey data on actual usage of the BSCS versions in 1970.

and often holds final responsibility for substance. This trend has affected all publishing companies.

Editors had mainly editorial skills and little subject matter background. Today, most firms have editorial staff organized by subject areas who are subject matter specialists, often with teaching experience and advanced degrees. Thus, since the NSF projects subject matter has been emphasized requiring greater subject matter competence from the staff. Increased market competition increased the pressure to bring products to the market on time and within budget.

Classroom Trials. Some NSF publishers have introduced classroom trials for testing preliminary versions of materials. However, most publishers have not fully incorporated them into curriculum production procedures. Classroom trials are expensive and the schools resist the publishers using their classrooms for profit. Teachers have not been convinced that classroom trials were a genuine development effort.\* Classroom trials required extra investment but did not provide any market advantage. Thus, for development to be institutionalized in publishing the schools will need to perceive publishers as creditable curriculum developers. The two non-NSF publishers have no plans to conduct any classroom trials.

Inservice Support Capability. Publishers strengthen their innovative capability by increasing inservice support to school districts. However, high levels of inservice support meet the same resistance from schools as classroom trials. Both NSF publishers have had limited success in offering inservice support to schools. Non-NSF publishers interviewed said they provide only occasional consultant services.

One NSF publisher provided free consultant service and curriculum resource centers. This effort came from the publisher's experience of working with the NSF project staff and learning about strategies, costs, and problems of providing inservice support. The company's salesmen learned how to stimulate resource personnel in supporting

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\* Hulda Grobman, *Developmental Curriculum Projects*, F.E. Peacock, 1970, p. 30.



change and functioned as change agents. The schools do not pay for this assistance. Some publishers have a stronger relationship to school districts than ever before.

#### INSTITUTIONAL CHANGES IN STATE ADOPTION BOARDS

The organizational factors of primary concern are the limits on number of approvals, whether only textbooks can be approved, and expensive sampling procedures.

##### Limits on Number of Approvals

Analysis of changes in state adoption board policies regarding the number of alternatives on approved lists is limited by the difficulty of obtaining historical data. The number of approved alternatives is often not a matter of formal policy as the data is buried in the files. Also, the number of approvals often differ by subject area and is subject to change from year to year.

Up to the mid-1930s, almost all states had single adoptions. But by 1955 all but California and Arizona had multiple adoptions and a number of states even had multiple adoptions for secondary and single adoptions for elementary.\* Teachers wanted a greater voice in materials selection. By the mid-1960s, the multiple adoption states increased numbers of approvals. In a fifteen year period the North Carolina adoptions grew from two to four per subject area and in Tennessee from four to 12, while Texas and Mississippi did not change.\*\* California went from being a single adoption state to listing 14 approvals in each subject area.

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\* Joseph I. Hall, "A Study of the Development of Legislation Affecting the Selection of Textbooks in the United States," Ph.D. Dissertation, Harvard University, 1958, Table 21.

\*\* Institute for Educational Development, "Selection of Educational Materials in the United States Public Schools," ED 044 030, 1969, Table 26; "Tennessee's Official List of Textbooks with Wholesale Prices, Retail Prices, and Copyright Dates," State Textbooks Commission, 1975; "Current Adoption Textbooks, 1975-1976," Texas Education Agency, Bulletin 757, Austin, Texas, 1975; Textbook Purchasing Form, Mississippi State Textbook Purchasing Board; and "North Carolina Textbooks," Division of Textbooks, Department of Public Education, 1975, Raleigh, North Carolina, 1975.

Increases in the number of state adoption listings are important for three reasons. First, it reduces the influence of state adoption boards on publishers' product decisions. Second, it reduces a publisher's advantage of being on the approved list and diminishes the return to "political influence" on the state adoption board. Third, it allows for greater decisionmaking at the local level.

#### Non-Text Materials

Prior to 1960, no state would include non-text materials in state-approved lists. Recent changes resulted in only five of the 22 adoption states still not approving inactive and other kinds of non-text materials. The seventeen states now approving non-text materials have either changed state laws or relaxed informal regulations.

Most of these changes correspond with the introduction of the NSF elementary science curriculum. However, good non-text materials in other subjects have been available for a long time--such as Science Research Associates reading program. High quality programs have been an important source of pressure to encourage state adoption boards to include non-text material.

#### Sampling Procedures

Lastly, the procedures for providing samples and pilot testing of curricula have been revised to lower the costs to publishers. The state textbook administrators and the publisher will negotiate a submission deal at a reduced cost.

#### Influence of National Curriculum Development

National curriculum projects have contributed to but *have not been* the main reason state adoption boards changed. They were mainly a strong source of pressure to increase curriculum alternatives and to include non-text book materials. Another source of pressure was federal programs such as Title II (Library Resources) of the Elementary and Secondary Education Act (ESEA), similar titles in the National Defense Education Act of 1958, and Title I ESEA (Compensatory Education). School districts could buy A-V media with federal money, thus bypassing the adoption board.

Circumstances for curriculum change were different in each state and not always traceable to NSF. However, the state curriculum supervisory staff in Idaho believed the NSF elementary science curricula to be far better than traditional programs. They convinced the adoption board to require schools to use the curriculum or some other "process-oriented" science program subject to state approval. But in Florida, a political scandal was the catalyst for the state legislature to rewrite the state adoption laws. The scandal broke when a local school district complained to the state education committee that the adoption board was disregarding their opinions. They had strongly recommended an elementary mathematics curriculum for adoption only to have it turned down. To make matters worse, the board could not find the district's review, a further indication that their proposal had not been considered seriously. Evidence of serious financial conflicts of interest among board members caused reforms to be instituted.

In California, Leo Ryan, a state legislator and former school teacher, questioned the state department of education about the state board's textbook approval process. The legislator believed it was wrong to omit teachers from materials selection, and to limit state-acceptable materials to hardbacked books and a single title per subject.\* Finally, in 1970 after much debate, a resolution was passed establishing a Joint Committee on Textbooks and Curriculum to review and revise the state's textbook legislation.

The reviewers made the following points about the state adoption process: current policy was not meeting the diverse needs of students; wasn't able to keep up with "educational development"; and wasn't cost effective because of high inventory costs. Restrictions of numbers of approved textbooks, exclusion of non-text materials, and excessive time required for approval were all factors further restricting development.

What emerges from these cases is two factors which influenced the changes. The increased numbers of available curriculum alternatives

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\* Conversation with Randall Young on March 5, 1976.

and the number of people questioning traditional policies were main sources of pressure which ultimately got state adoption boards to change. *It is our opinion that this climate for change may not have been solely caused by but was heavily influenced by the national curriculum projects.*

#### INSTITUTIONAL CHANGE IN LOCAL SCHOOL DISTRICTS

Finally, we will consider institutional changes at the school district level affecting incorporation of development. Despite the scarcity of data we will consider local curriculum decisionmaking processes, materials development, inservice support capability, and organizational factors.

#### Decisionmaking Strategies

Decisionmaking at the local school district shifted from goal-setting to materials selection. The result has been increased decentralization of authority. The work of curriculum decisionmaking had been goal-setting and was performed through separate organizational processes. This emphasis on goal-setting stemmed from the theorists like Franklin Bobbitt as far back as the early 1900s.\* Bobbitt's contribution was the development of a procedure for determining educational goals. These goals were derived from analysis of adult tasks and was called task analysis.\*\* Committees of teachers, administrators, and outside-hired experts reviewed the curriculum and prepared goal statements or curriculum guides. It was assumed that teachers would be able to find means for achieving the goals stated in the guidelines, including the selection or preparation of appropriate materials.\*\*\*

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\* Herbert M. Kliebard, "Systematic Curriculum Development, 1890-1950: An Interpretive Survey," Paper presented for the NIE Conference on Curriculum Development, November 1976, pp. 21-31; and Elliot N. Eisner, "Franklin Bobbit and the Science of Curriculum Making," *School Review*, Vol. 77, No. 1, Spring 1967, pp. 29-47.

\*\* Franklin Bobbitt, *How to Make a Curriculum*, Houghton Mifflin, Boston, 1924, p. 8; and Herbert Kliebard, *op.cit.*, pp. 31-44.

\*\*\* Murray G. Phillips, "Learning Materials and Their Implementation," *Review of Educational Research*, Vol. 36, No. 3, June 1966, p. 373; and William F. Laban, "Modern Trends in Science and Their Effects on Local Curriculum Development," *School Science and Mathematics*, Vol. 68, No. 2, 1968, pp. 141-144.



In the past, decisions regarding materials tended to be made informally by high-level administrators, with input from district staff, teachers, and parents. Since the 1950s, materials selection has become an important part of the curriculum decisionmaking process and the old guidelines have been replaced by behavioral objectives. Curriculum theory has broadened to include instructional materials.

#### Materials Development

The new curriculum contributed to the expansion of the number and kind of curricula materials, but not necessarily increased teacher participation in their selection. The 1975 survey of materials usage (referenced earlier in this report) states that 45 percent of the 12,000 responding teachers report they play no role in materials selection; 30 percent report less than one hour per year; and the remaining 25 percent report an average of 10 hours per year. This data points out how low teacher participation still is in materials selection. Likewise, Schaffarzick found local school district assessments of alternative materials were rarely conducted and, if they were, rarely consisted of more than "...hasty examinations...observations of use in a small sample of other schools (usually one other school), and informal conversations with users of the programs being considered."\*

Neither the national curriculum projects nor the NSF have institutionalized the decisionmaking process for development in local school districts. The materials development projects have been largely concerned with supporting school usage of curriculum innovations. Practically no effort has been directed to developing and supporting curriculum decisionmaking.

The major exception is the funding that NSF has provided for the FUSE (Federation for Unified Science Education) network. FUSE involves both curriculum and curriculum decisionmaking process innovations. The curriculum innovation is that subject matter is organized into modular units each directed to a particular theme. These themes may be a scientific concept (e.g., equilibrium or energy), scientific

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\* Jon Schaffarzick, op. cit., p. 172.

processes (e.g., a river), or problems of science in society. Each unit is made up of both commercially and locally developed materials. Decisions on dropping themes or adding new ones are made jointly by the entire teaching staff. Through the network maintained by the FUSE center, different sites swap information about their programs.

#### Inservice Support Capability

Our impression is that resource allocations to inservice training have increased but that progress toward integrating inservice training with goal-setting and materials selection has been slow. A study of 17 large cities found that while primary influence in materials selection is at the building level in 12 of these school districts, only *two* delegate responsibility and allocate the resources for carrying out inservice programs at the building level.\* National curriculum development points up the need for inservice support of teachers. Their associated implementation activities provide models for school districts.

#### Organizational Factors

Changes in organizational factors included physical facilities for science and material support for science curriculum activities. Although no longitudinal data could be found to make comparisons, relevant changes include increases in school district budgets for science equipment and materials other than textbooks, institutionalization of a capacity to supply material resources for science programs, and the availability of more space for science activities. Such changes may be largest at the elementary level because of the introduction of enactive materials. Some school districts like Fairfax County, Virginia have adapted to the new curricula by establishing a science center. This science center (initially established by a participant in the ESS project) produces kits for the three NSF elementary science curricula and distributes them to interested teachers. Much of the work is done by students. The center supports workshops

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\* I. Ezra Staples, "Impact of Decentralization of Curriculum: Selected Viewpoints," Association for Supervision and Curriculum Development, 1975, p. 22.

for teachers, curriculum development activities, and after-hours science programs for students.

The national projects had additional unplanned effects on commercial publishers that we will look at in Section V.

V. EFFECTS OF FEDERAL CURRICULUM PROGRAM  
ON COMMERCIAL CURRICULUM

Adoption figures for federal programs do not necessarily reveal the total number of students experiencing the federal program. It appears that innovations from the federal programs were incorporated into science textbooks not funded by the federal government. This means that the impact of the federally-funded projects is far greater than first thought. This unplanned-for effect is called secondary impact. To find out the extent of secondary impact we asked the following questions:

- ° What evidence is there that federally-funded curricula programs influenced the content of commercial programs?
- ° What are the *forces* that influenced publishers to incorporate these innovations?

Answers were found by tracing the incorporation process for three innovations: The innovations selected, common to several national curriculum projects, were *updating subject matter content, organizing material around conceptual schemes, and designing curricula around manipulative materials*. The first two innovations were analyzed by examining several editions of Holt, Rinehart and Winston's *Modern Biology*. This book had dominated the high school biology market for at least a decade prior to the federally-supported BSCS programs. We analyzed a large number of other commercial programs as well.

Each of the following sections describes one of three longitudinal studies conducted to assess the effects of innovations developed during the curriculum reform movement. How were these innovations incorporated by commercial publishers into their programs?

UPDATING AND REDISTRIBUTING THE SUBJECT MATTER

The primary goal of the early science projects was to produce textbooks reflecting current scientific knowledge. "Traditional"



textbooks portrayed an outdated outlook inconsistent with development in the scientific community. Increased attention had been paid to scientific and technological applications while minimizing theoretical concepts.

In light of these considerations, the BSCS, CPA, CHEM Study, ESCP, and PSSC projects all included as a central objective, *updating subject matter content*. In addition, the new textbooks changed topic emphasis to reflect current knowledge.

#### Levels of Biological Organization

*Levels of biological organization* was one of the dimensions we studied to see if traditional commercially-developed programs incorporated the BSCS content emphasis into their textbooks. Program developers identified seven levels of biological organization reflecting boundaries of inquiry within the discipline of biology. These are:

| <u>Level</u>                     | <u>Sample Topic</u>                                           |
|----------------------------------|---------------------------------------------------------------|
| 1. The Molecular Level           | Biochemical Reactions in Plants                               |
| 2. The Cellular Level            | Cell Division                                                 |
| 3. Organ and Tissue              | The Digestive System of a Mammal                              |
| 4. The Organism as an Individual | Territorial Behavior of Geese                                 |
| 5. The Population                | Factors Influencing Population Size of Various Animal Species |
| 6. The Community                 | The Food Web in a Pond                                        |
| 7. The World Biome               | Worldwide Distribution of Flora and Fauna                     |

Traditional biology courses spent most of the classroom time on Level 3--the organ and tissue level--and failed to devote adequate attention to either Levels 1 or 2--molecular or cellular--or to the four higher levels of organizations--Levels 4, 5, 6, and 7. The national curriculum projects advocated reallocating the amount of time spent on these topics.

### General Methods

A content analysis methodology was developed to assess recent revisions of Holt's *Modern Biology* for changes in subject matter emphasis. We asked:

- ° How and when had the content emphases of the traditional textbook program change?
- ° To what extent have the changes been consistent with the changes in emphases advocated by the BSCS program?

Subsections were the basic unit of analysis. A subsection is a portion of a chapter addressing a single topic. *Modern Biology* subsections are typically 3 to 5 paragraphs long. Their meaning is not altered by removal from the chapter.

Data was analyzed in two stages. The first stage was a revisions analysis. Subsections were identified that had been either deleted or added during successive revisions of the textbook. We used the data from this analysis to determine:

- ° when the publishers had made the changes;
- ° the magnitude of those changes; and,
- ° the overall extent to which the text had changed over time.

During the second stage these subsections were analyzed to see how similar they were to BSCS topics providing incorporation data. (See Appendix A for descriptions of the analyses.)

### Results of the Analyses

From 1956 until 1963, the predominant net effect of the *Modern Biology* revisions was to add subsections in categories deemphasized by the BSCS developers.

Both the *revisions* and *levels of emphasis* analyses point out that the BSCS innovation, updating and redistributing subject matter, was incorporated into the commercially-developed *Modern Biology* program. The revisions analysis showed that of the six *Modern Biology* editions

released since 1965, five reflected an amount of change in the written text consistent with copyright requirements. Editions following the release of BSCS textbooks reflected even greater changes.

However, the *Modern Biology* publishers did not follow the BSCS recommendation to deemphasize the organ-tissue-morphology area. This is not entirely unexpected as it occupied a considerable portion of the biology curriculum. Publishers are smart to be cautious about eliminating sections of a textbook with a successful history. It should be noted that the *Modern Biology* publishers added subsections at a conceptual level consistent with other BSCS recommendations for improving biology. Data collected from themes analyses revealed that 65 percent of the changes made were at the organ-tissue-morphology level. Material in this category was treated to thematic conceptualization. Close to 70 percent of the subsection changes in *Modern Biology*, starting with the 1963-1965 edition, pointed to a redistribution of content consistent with BSCS. Prior to 1965, over 60 percent of the changes had been consistent with BSCS.

#### SKILLS EMPHASIS: THE INCORPORATION OF CONCEPTUAL SCHEMES

Determining criteria for selecting and organizing the content of a new curriculum program is a major challenge. The BSCS curriculum developers found more information available than could ever be included in a single course. Developers eliminated large amounts of material and structured what was left to meet instructional goals.

#### The Innovation

NSF science project developers organized subject matter content around conceptual schemes derived from the discipline's theoretical structure. Developers believed that this way of structuring courses could enhance a student's conceptual thinking. Some believed that conceptual thinking contributed to problem solving skills. Advocates of the conceptual scheme approach believed it would foster a learner's capacity for integrating new and changing knowledge, specifically conceptual skills. fostered the ability to generate new ideas, define

problems, organize and make interpretations of data, formulate principles and provide explanations for observed phenomena.\*

In the early NSF science curriculum projects, conceptual schemes were operationalized as themes woven throughout the text. The themes fell within the *substantive* or *process* dimensions of the disciplines. Chemistry and physics are expressions of fundamental theories, in contrast to earth science and biology which are expressions of interrelated concepts. Process themes generalized across science as they encompassed the basic methodological underpinnings of all scientific endeavors.

#### Modern Biology Incorporation of BSCS Conceptual Schemes

Evidence of commercial publishers adopting the conceptual schemes approach was found by examining *Modern Biology* revisions for change consistent with the BSCS themes. Subsections were the unit of analysis; each added or deleted subsection was analyzed for its thematic content.

#### Nature of Theme Incorporation

Evidence of incorporation activity was found in the text covering all levels of biological organization. This is illustrated by theme distribution patterns in newly added subsections of the 1965 edition of *Modern Biology*. Each of the themes was introduced into several subsections at the Molecular-Cellular, Organ-Tissue-Morphology, and Behavior-Population-Biome levels. Themes function as unifying threads connecting different content areas. (See Table 6.1.)

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\* Paul deHart Hurd, *New Directions in Teaching Secondary School Science*, Rand McNally and Company, Chicago, 1969. There is no precise agreement on the definition of a conceptual scheme. In a broad sense conceptual schemes can be thought of as a network of related concepts in a systematic way. Such schemes reflect the overriding uniformities or regularities that guide the interpretation of observations in systematic inquiry. Hurd (1969) present an exceptionally clear and insightful discussion of the role of conceptual schemes in science curriculum development. Other writings that elucidate this area include Broudy et al., (1971) and Schwab (1971).

\*\* Ibid.



Varying Patterns of Theme Incorporation. Each theme was incorporated into the text in a somewhat different form. Subsection excerpts from the 1965 version demonstrate how *Modern Biology* publishers incorporated the theme of the "complementarity of organism and environment." The notion that biological entities influence and are influenced by their environment is embedded unsystematically throughout the text.

In contrast is the systematic incorporation of the theme "change of living things through time." This theme appears quite frequently in both the introductory and summary subsections. The *Modern Biology* excerpt on seed plants is typical of others on the various phyla of the plant and animal kingdom.

The rise of seed plants

The first forests appeared on the earth during the Devonian period of the Paleozoic era (Figure 22-1). Growing among the club mosses, horsetails, and ferns that composed these forests were the first seed plants, known as *seed ferns*. These ancient plants, now long extinct, were evolutionary products of the fern and ancestors of the modern seed plants that dominate the vegetation of the land today. Seed ferns were prominent in the swamp forests of the Carboniferous age. During the Permian period of the late Paleozoic era, they are believed to have given rise to other forms of seed plants, including cycads and conifers.

With the dawn of the Mesozoic era some 200 million years ago, the climate of the earth became warmer and drier. These climatic changes led to the gradual disappearance of the seed ferns during the Triassic period. However, other seed plants continued to increase in number. The Jurassic period of the Mesozoic era marked the appearance of flowering plants, the most highly evolved seed plants. These plants developed rapidly during the Cretaceous period and have maintained their position of dominance to the present day. (p. 310)

This theme is also in three chapters not included in versions of *Modern Biology* before 1965 on the theory of evolution.

New Curricula as Model Programs. The theme History-Scientific is consistent with the desire for a history of how biological knowledge is generated. To see how closely *Modern Biology* followed the BSCS approach we compared the 1960 and 1973 editions to see if there was a marked difference between the two versions. They noted that (1) biological findings were presented in historical context, and (2) attention had been given to the inquiry and investigative phases of biological science.

A cursory comparison of the "unchanged" text of the 1960 and 1973 versions of *Modern Biology* suggests that it is likely that intact subsections could have been rewritten to include themes.

We designed a separate coding category for the following three themes:

- ° the change of living things through time: evolution;
- ° the complementarity of organism and environment; and
- ° the complementarity of structure and function;

and combined the following two themes into a single coding category called "History-Scientific Processes":\*

- ° science as enquiry; and
- ° the history of biological conceptions.

Extent of Theme Incorporation. Sixty-eight percent of the changes in the 1963 edition were consistent with the BSCS thematic approach, as compared to 29 percent in the 1960 edition. Theme incorporation is strongest in the 1965 edition with a consistency factor of 72 percent. It drops off in the 1969 edition with a factor of 68 percent, and in the 1973 version consistency is down to 53 percent. *Modern Biology* publishers devoted a discipline-oriented text. Since 1965, a total of 183 subsections without themes have been deleted from the *Modern Biology* program. During this same period a total of 122 subsections having themes were added.

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\* A summary of the criteria for coding themes appears in Table 6.1. Note that it was possible for a single subsection to incorporate more than one theme.

Table 6.1

DISTRIBUTION OF 1965 THEME ADDITIONS AMONG  
BIOLOGICAL LEVELS OF ORGANIZATION

| Theme Category                  | Level of Biological Organization |                                 |                                 |
|---------------------------------|----------------------------------|---------------------------------|---------------------------------|
|                                 | Molecular-<br>Cellular           | Organ-<br>Tissue-<br>Morphology | Behavior<br>Population<br>Biome |
| History-Scientific Processes    | 13                               | 10                              | 13                              |
| Structure-Function              | 1                                | 1                               | 3                               |
| Evolution                       | 4                                | 8                               | 22                              |
| Organism-Environment            | 11                               | 8                               | 24                              |
| Total Subsections Added in 1965 | 36                               | 32                              | 55                              |

In 1960 only 40 scientists were mentioned in the text as compared to 69 scientists in 1973. The earlier version mainly presented the conclusions of an investigator's work and in eight instances a description of the experiments. In contrast, the 1973 text details 22 biological experiments and explains how researchers build on one another's work.

*Modern Biology* publishers adopted from BSCS an approach for presenting the history of biology. This approach is called the "narrative of enquiry." BSCS associate Joseph Schwab described it as a presentation whereby conclusions are formulations of the evidence found in scientific investigations. The BSCS used it as the context for presenting biological facts in terms of principles, theories, and ideas. Our content analysis data supports the view that 41 added subsections incorporated the theme of History-Scientific processes while seven of the deleted subsections contained the same theme.

MATERIALS PRESENTATION: NON-TEXTBOOK FORMATTING

A quick glance at the NSF elementary science programs reveals how its physical format differed dramatically from traditional programs.

Instead of a standard textbook geared toward classroom seatwork, the "new" curricula contained bits of science materials and equipment enabling scientific investigations and experiments to be part of the classroom.\*

The curriculum developers believed that direct experience with scientific phenomena makes learning more meaningful. Students seem to learn science better when they confront problem situations and propose alternative solutions. The processes of science helped students learn information-seeking strategies. Active involvement in observation, hypothesis generation, measurement, etc., was thought to be central to the learning process. This notion was reinforced by leading educational psychologists whose theories stressed the importance of structured experiences for learning.\*\*

#### FORCES INFLUENCING INNOVATION INCORPORATION

All three inquiries reported in this chapter indicate that educational publishers have incorporated innovations of federally-sponsored curriculum projects into their own commercially-developed programs. Moreover, the data supports the argument that publishers were motivated by the innovations in the federally-sponsored projects:

- ° After the innovation had appeared in materials developed with federal funds, it was incorporated into commercially-developed curricula.
- ° Within several years following publication of federally-developed materials the movement peaked and leveled off.

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\* Varying amounts of written materials are also included in the new curricula program. The written materials tend not to be in textbook form, however, and more typically would be pamphlets and workbooks and even though there are written materials included, the programs are designed for an activity-oriented classroom.

\*\* Glenn O. Blough and Julius Schwartz, *Elementary School Science and How to Teach It*, Holt, Rinehart and Winston, Inc., New York, 1969; Joe L. Frost and Thomas G. Rowland, *Curricula for the Seventies: Early Childhood through Early Adolescence*, Houghton Mifflin Company, Boston, 1969; Lee S. Shulman and Pinchas Tamir, "Research on Teaching in the Natural Sciences," in R.M.W. (ed.) *Second Handbook of Research on Teaching*, Rand McNally and Company, Chicago, 1973, pp. 1098-1148.



#### NEW CURRICULA AS DEMONSTRATION PROJECTS

These findings corroborate our contention that the improved approach demonstrated by federally-financed curriculum projects was copied by commercial publishers. It is hard to deny the existence of the model programs effect. However, compelling evidence suggests other forces played an important role as well.

The rationale for the early curriculum projects was to update the content of various high school courses to communicate the current state of scientific methods and knowledge. Articles in trade journals frequently discussed innovations similar to those of the new curricula. Clearly, science publishers knew of these advances and approaches long before the publicly-funded projects drew attention to them. However, new developments in science were not incorporated into textbooks until ten to 30 years later. In the meantime, the new material became appendixes. Most textbooks include far more information than can be covered during the school year. The majority of students were never taught the new material.

Drafts of the BSCS materials were available to *Modern Biology* publishers while the 1963 edition was being written. Holt waited two years after BSCS was published before incorporating the innovations into their text.

#### Other Forces Influencing Incorporation

Commercial publishers were motivated by market and social forces.

Market Forces. *The commercial success of the new curricula programs created market pressures that mitigated in favor of innovations from the new curricula being incorporated.*

Student usage figures for BSCS textbooks show how these forces operate in the case of high school biology. Prior to 1963, *Modern Biology* was reputed to hold 80 percent of the high school biology market. By 1964, an estimated 614.2 million students were using BSCS texts, thus reducing the *Modern Biology* market share substantially. At this point its publishers became convinced that BSCS textbooks were threatening its long held major share of the market. They took action to regain lost sales.

The timing of changes in *Modern Biology* makes it clear the publishers acted in response to the market. The *Modern Biology* publishers did not respond until the BSCS program created a demand for up-to-date curriculum. They complied with a program in line with BSCS, but still retaining many of the features making the earlier editions successful. As the text regained its former market structure, the amount of innovation incorporated in any one revision is most like pre-1965 levels.

The elementary science programs were based on manipulative--non-text--materials. These new curricula programs contributed to the demand for teaching elementary science through inquiry. This interest in activity-oriented programs was apparently sharp enough to convince many publishers to develop manipulative-oriented elementary science programs.

Social and Value Considerations. Social and value considerations enhanced the secondary effects of the publicly-financed programs. *The proponents of the new curricula formed a powerful and well-respected constituency who actively worked to bring about the acceptance of their ideas.*

The concept of evolution was incorporated into the high school biology curriculum despite intense opposition. Publishers considered it a risky and inappropriate innovation. Evolutionary concepts are among the most firmly established generalizations of modern science. Nevertheless, commercially successful biology textbooks included very few references to evolution prior to the 1963 release of BSCS.\* Grabiner and Miller point out how the much publicized Scopes trial resulted in less teaching of evolution.

Evolution in the average high school textbook was treated superficially. The reason was that the New York-based publishing industry censored itself to fit state textbook adoption boards in the South. Publishers believed that if they included evolution in their textbooks they would lose the southern market. Therefore, the topic was eliminated from most textbooks.

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\* Judith V. Grabiner and Peter D. Miller, "Effects of the Scopes Trial," *Science*, Vol. 185, 1974, pp. 832-837; Dorothy Nelkin, "The Science-Textbook Controversies," *Scientific American*, Vol. 234, 1975, pp. 37-50.

Black reinforces this view as the Tennessee legislature didn't repeal the state's anti-evolution law until May 1967.\* During that same time period Mississippi and Arkansas had anti-evolution statutes and the state commissioner of education in Alabama maintained that BSCS books would not be used in the state's schools as long as he was in office.

The situation is quite different today. Each of the states mentioned has adopted at least one of the BSCS versions as well as the post-BSCS version of the *Modern Biology* text which includes a treatment of evolution. These programs are appearing on the approved lists in many of the adoption states. Recent editions from other major publishers consistently emphasize evolution and are still adopted in the South.\*\*

The source of this change has been traced to the explosive 1964 textbook adoption hearings in Texas. Since the state of Texas pays for all State Board approved textbooks, local schools invariably choose these books. Nevertheless, the BSCS publishers took a great risk when they submitted the three BSCS versions to the Texas adoption board. The submission launched a heated controversy pitting anti-evolutionist fundamentalists against proponents of BSCS. Despite this bitter opposition, the textbook selection committee recommended all three versions for the state approved list. The Board of Education approved the selection committee's recommendations. In the following years nearly half the schools chose one of the three BSCS texts approved by the state.\*\*\*

Until the new curriculum projects took on the challenge of evolution, publishers were unwilling to risk losing the southern market. Once the barriers in key states eased publishers began to emphasize evolution in the curricula. BSCS had provided a test case for evolution being included in high school biology texts.

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\* Hillel Black, *The American Schoolbook*, William Morrow and Company, Inc., New York, 1967.

\*\* Raymond F. Oran, Paul J. Hummer, Jr., and Robert C. Smoot, *Biology*, Charles E. Merrill Publishing Company, Columbus, Ohio, 1976.

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## VI. FEDERAL SUPPORT OF SCHOOL-LEVEL IMPLEMENTATION ACTIVITIES

After reviewing the activities and effects of the national curriculum projects, the issue of *implementation* stands out as critical to curriculum innovation. This chapter describes the changes caused by school-level implementation and the strategies proven most useful to produce these changes.

Three different changes can be distinguished for the purpose of this discussion: (1) more adoptions of specific curricula in schools than would normally occur, (2) more complete incorporation by teachers of the innovations; and (3) the indirect effect of institutions changing to fit the high level of curricula usage. Our discussion will be limited to the first two changes. The third was discussed in Section IV.

Our analysis will rely upon the available evidence for NSF's implementation activities. These activities included two kinds of projects: one upgraded teacher's subject matter competency and the second supported implementation for specific curricula. Within the category of subject matter competency, teachers attended Academic Year Institutes, Summer Institutes, and Inservice Institutes. To learn how to implement the curricula, teachers attended Awareness, Teacher-centered, Resource Personnel, and School System projects. Funding for these projects was provided both directly through implementation programs and indirectly through curriculum development.

*Awareness* projects disseminated information about new science curricula with a strong emphasis on NSF-developed materials. These projects were conducted by a university faculty member with curriculum supervisors and school administrators attending. Adoption of new science programs was encouraged by providing information on sources for support of teacher training.

*Teacher-Centered* projects provided training in the implementation of one or more NSF-developed curricula. These courses were led by university professors and attended by teachers from different school



districts. The intent of summer and school-year workshops was to train teachers new to making adoption decisions.

*Resource Personnel* projects trained school personnel to initiate curriculum training efforts in local school districts. These projects were limited to persons responsible for curriculum implementation in local districts. Personnel included college faculty, school administrative personnel, curriculum supervisors, principals, and resource teachers.

*School System* projects involved one or more school districts forming a committee to work with university faculty for curriculum improvements. Funds were used to adapt materials to local needs, in-service training for teachers, and the purchase of needed materials, equipment and supplies.

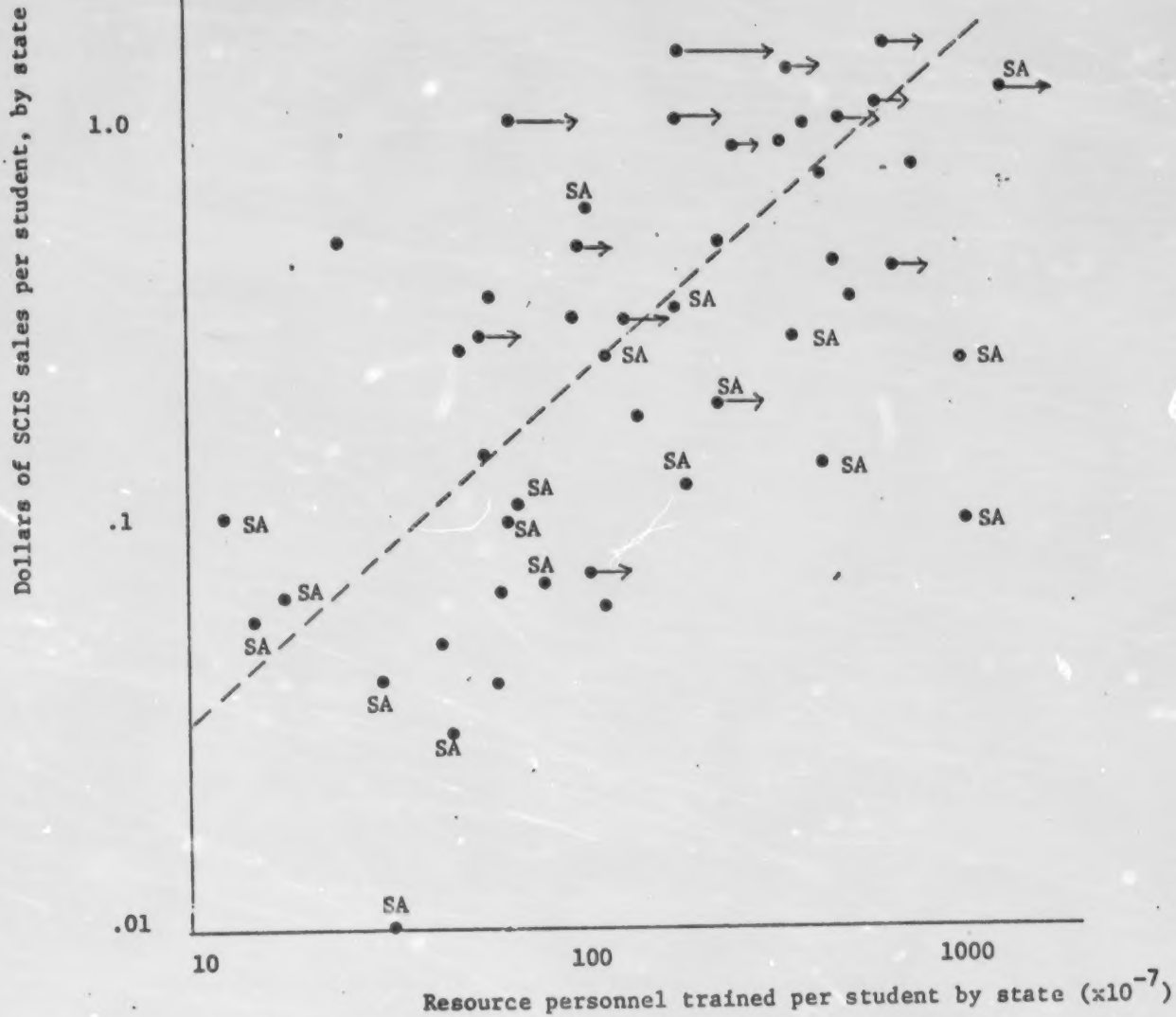
#### Effects on Adoption

The Resource Personnel and Teacher-Centered projects offered the most evidence about adoptions.

Resource Personnel. The most useful data on resource personnel training that we found described 800 resource personnel trained by the Science Curriculum Improvement Study. The data indicated their strong effect on initial adoptions of the SCIS curriculum. The results indicate that initial adoptions were highly correlated with the geographic location of the SCIS-trained resource personnel (Fig. 6.1). Since the average level of adoptions is lower in those states where few resource personnel were working, the implication is that without the training of resource personnel very few teachers would have adopted SCIS. However, the geographic clustering could be explained by the fact that adoptions may have spread through word of mouth.

Another explanation for its success may be the kind of training SCIS provided. Let us examine its main features:

- ° SCIS accepted only participants whose home institutions had committed to improving their science curriculum.
- ° Content of the week-long training sessions was planned by the participants after they had tried out SCIS materials.



SOURCE: Sales data were provided by Rand McNally, the SCIS publisher. Resource personnel data were from lists of trainees provided by SCIS.

NOTES: States with the long arrows had two or more resource centers. Rhode Island and New Hampshire had no resource personnel. These states are close to Massachusetts which had three resource centers.

Fig. 6.1--Correlation of resource personnel trained to adoptions of the SCIS curriculum (1970-1974)

- Much of the week was spent visiting staff members and teachers in their classrooms, as well as participating in discussions on development problems.
- A strategy for implementing any innovative science program was taught.
- After the training, the SCIS director maintained contact through newsletters and personal contact.

Data reviewed suggests that federal implementation support produces a third of the initial adoption. Resource personnel often initiated local implementation efforts and provided support for local area teachers using the curriculum. Table 6.2 points out that over 50 percent of high school science teachers attended at least one NSF training project. Maximum usage reached by the early high school science curricula was also over 50 percent. Similarly, in 1976, 14 percent of the elementary teachers reported receiving specific NSF science curriculum training.\* And 15 percent of the elementary teachers surveyed were using an NSF science curriculum. During the period when NSF implementation funds were temporarily terminated, publishers reported that sales decreased as well. Budget pressures combined with the "back to basics" movement may account for the decline.

#### Effects on Incorporation

One source of evidence on incorporation is the studies describing the effects on teacher behavior from participating in the curriculum-specific training projects.\*\* Despite some problems with experimental designs, our impression is that the effects on teacher behavior are substantially greater for non-textbook curricula than for textbook-only programs. Bivariate correlations of all 85 variables were

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\* P. Kenneth Koski

\*\* A.L. Balzer, "A Review of Research on Teacher Behavior," ERIC Science, Mathematics, and Environmental Education Clearinghouse, Ohio State University, Columbus, Ohio, 1973.

Table 6.2

PARTICIPATION OF HIGH SCHOOL TEACHERS IN  
NSF FUNDED TRAINING PROJECTS

| Number of Training<br>Projects Attended              | Biology<br>teachers | Chemistry<br>teachers | Physics<br>teachers | General<br>Science<br>teachers |
|------------------------------------------------------|---------------------|-----------------------|---------------------|--------------------------------|
| Funded by NSF *                                      |                     |                       |                     |                                |
| One                                                  | (33)                | (37)                  | (39)                | (29)                           |
| Two                                                  | (16)                | (20)                  | (21)                | (13)                           |
| Three or more                                        | (1)                 | (2)                   | (3)                 | (1)                            |
| SUBTOTAL                                             | 50                  | 59                    | 63                  | 45                             |
| Funded by other<br>federal, state or<br>local agency | 9                   | 8                     | 5                   | 10                             |
| No training project<br>attended or no<br>response    | 41                  | 43                    | 32                  | 44                             |
| TOTAL                                                | 100                 | 100                   | 100                 | 100                            |

SOURCE: Martin Herskhowitz, op.cit., Tables A1, A2, A3, and A4.

compiled. The findings were that: (1) teaching mode of lecture-discussion was negatively correlated with participation in a science curriculum project and classroom usage; (2) teaching mode of laboratory usage was positively correlated with participation in a science curriculum project and its use in the classroom; (3) that teaching mode of group laboratory was positively correlated with two new science curriculum variables but negatively correlated with textbook usage; and (4) that teaching mode of small group discussion, independent study, and field excursions was not correlated with any of these variables. \*

These results indicate that training plus use of new science curriculum materials is positively associated with a laboratory

\*The "F" test of significance was a correlation of significantly different than zero at 0.001 confidence level.



environment. Teacher use of the new science materials was highly correlated with participation in a training activity. Seventy-seven percent of the variance in the new science materials usage was explained by training activity participation.

Length of Usage. The only result on the length of usage is from the study of teacher-centered training projects discussed earlier in the chapter. Usage apparently falls to about 50 percent of the initial adoptions with no substantial differences between teachers participating in the training project and those not participating. The rate of decline was less for teachers starting the projects in 1970 than those starting in 1973. Earlier adopters took the largest risk and had more at stake.

#### Alternative Implementation Strategies

Although the quality and quantity of existing research was inadequate to draw any firm conclusions, the trend of the evidence was that the training activities did not make a substantial difference in teacher incorporation of national curriculum innovations. Whether these findings implied that direct implementation support cannot be effective or that the wrong strategies were followed was not clear.

NSF's implementation projects have followed the summer workshop model. Teachers go to a university for a few weeks or curriculum training and return to their classrooms. The assumption is that implementation does not require direct support for teachers in their organizational environment.

Another strategy has been followed by one of the SCIS university-based resource centers. They followed a phased approach of successively increased usage over time. First, the project director approached influential administrators in a school district to get their support for the implementation program. This required close to a year of meetings to provide information and to get the administrators to use the curriculum.

Once administrators made a commitment, partially financial, volunteer teachers were encouraged to participate in pilot curriculum projects. Once the projects were acceptable to the administrators,

NSF implementation funds were used for district-wide teacher training. Schools with only a few interested teachers were discouraged from participation, that is, until a "critical mass" of teachers committed to the projects. Inservice training tried to convince teachers that the curriculum was worthwhile and identified candidates for school resource teacher positions.

Candidates for resource teachers were given further training in the SCIS curriculum and its implementation. They provided day-to-day assistance to teachers adopting the curriculum by conducting periodic teacher meetings. In addition, the director selected the most effective resource teachers to consult with neighboring districts. The central school district supported after-hours workshops for teachers developing their own science materials and/or increasing their skills.

The success of this project suggests a federal implementation strategy supporting more broadly-based resource centers that would help schools implement curricula.

#### SUMMARY

Incorporation of innovations from the national curriculum projects in the school curriculum would have been substantially lower without federal support of implementation activities. Their most effective course of action was through stimulating additional adoptions rather than more implementation. The increase in adoptions is apparently about a third and may be substantially higher. Adoptions increase incorporation to the extent that materials structure teacher behavior and subject matter choices, and that the materials continue being used. Federal implementation funds apparently affect adoptions through accelerating a highly localized process dependent upon colleagues' relationships and demonstrations of successful use. *Implementation strategies that tend to increase local administrative support, provide on-site resource personnel, reinforce peer relationships, and encourage higher levels of use might increase implementation.*

## VII. CONCLUSIONS

We have examined the effects of national curriculum projects on educational institutions. We looked at the role of curriculum development in terms of its effect on classroom learning and educational institutions. Our purpose was to assess the implications of future federal support of national curriculum development.

The basic premise is that the school curriculum is influenced by the interrelationships of the publishing industry, the state adoption committee, and local school districts. Our assumption was that *national curriculum development* changed the character of the institutions and the way they interacted with one another. We examined these changes and concluded that national development did affect the system in broad and important ways.

### NATIONAL INFLUENCES ON THE CURRICULUM POLICYMAKING SYSTEM

Prior to the NSF projects the school curriculum was highly uniform from school to school. The structure of subject matter taught and the way children interacted with the subject matter was the same as it has always been. One textbook per subject area typically dominated the market for many years. Little or no changes were made from edition to edition.

Classroom procedure was characterized by a teacher lecturing to students, and students responding to teacher questions often by reciting factual answers. The role of the student was a passive one.

In effect, there was a national curriculum even though the federal government did not have the power to determine it. We hypothesize that much of the uniformity and stability in the school curriculum at the time of the first NSF national curriculum was due to the non-developmental character of education.

### LIMITATIONS ON INNOVATIONS

Only publishers with large market shares earn enough money to invest in major curriculum development. Market incentives do not favor

abandoning a successful product for investment in innovative alternatives. Instead, publishers often invest available funds in product improvements. Smaller publishers have the incentive to develop major alternatives to established curricula but not the financial resources. They are not able to invest in those options and refinements affordable by leading publishers.

Economic influences also maintain the stability of the curriculum. Major curriculum development costs over several hundred thousand dollars per year. Only a small proportion of school district budgets are allocated to the purchase of materials. Furthermore, some subject areas receive more money than others. Distribution of revenues is fixed according to departmental structures, teacher staff sizes, and graduation requirements.

One factor limiting innovative development was centralizing curriculum decisions in state and local district textbook adoption boards. These institutions restricted textbook alternatives available to teachers. However, centralization was advantageous to publishers with successful products. Year after year, they could continue to satisfy the adoption groups without investing in innovation.

Schools' organizational structures and policies can also inhibit curriculum innovation at the classroom level. For example, the school structure can impede the reorganization of a subject area and the inclusion of non-textbook materials into the curriculum. Reorganizing the subject area was needed to implement the problem-solving approach advocated by BSCS. Furthermore, non-text materials are far more consistent with the way children learn than traditional modes of instruction. The discipline orientation of the educational system inhibits reorganizing subject matter, and the exclusionary policies of state adoption boards impeded the incorporation of manipulatives and hence a salable curriculum.

A second factor is teachers' dependence on instructional materials for competency. Teachers rate commercial materials to be their most valuable curriculum resource. Over 90 percent of classroom time is organized around commercially produced materials. Leading commercial materials are often used as references in both state and local



curriculum guideline writing activities. Furthermore, teachers using one textbook for years often feel "uncomfortable" with new textbooks.

Publishers found that implementing innovation into the school curriculum was not easy. School districts are not organized to integrate innovation. Publishers often do not do more than conduct brief workshops to assist schools and teachers in making curriculum changes. The organizational structure of the school separates decisions about curriculum from those about inservice training workshops. Thus, publishers are reluctant to invest in major curriculum alternatives without sufficient support from the schools.

Thus, the national curriculum projects found enormous resistance from institutions inside the organizational channels of major federal education programs. But an important point is the large number of private organizations outside the system that effectively work against the incorporation of implementation as well. Publishers, testing services, and school accreditation agencies all influence the core curriculum of schooling and are private organizations outside direct federal pressures. Even though state adoption boards are public, they are largely independent of state education agencies.

In order for the national curriculum programs to be implemented, organizations both *inside and outside* the jurisdiction of the federal education system had to cooperate. To what extent they supported the programs will be summarized in the next section.

#### Effects of National Curriculum Projects

The National Science Foundation proposed substantial changes in the content and presentation of subject matter. Specific innovations in natural science curricula included replacing outdated information with up-to-date scientific knowledge; skirting subject matter away from facts to unifying concepts; and organizing subject matter around a problem-solving approach. These innovations were intended to introduce active learning into the classroom. Students at all grade levels learned how to question as the teaching mode became a "narrative of inquiry."

Classroom materials. We have limited our analysis to the science projects, mainly BSCS. The data pertaining to BSCS were presented in several places throughout this report. Textbook sales data show that classroom usage of the BSCS textbooks grew steadily from 1963 to approximately 50 percent of enrolled students in 1970, and then declined to a current level of about 30 percent.

Available evaluation research studies show that learning outcomes do change in the direction of BSCS objectives. One study points out that student recall of subject matter covered correlates with the subject matter in the texts used. The classroom evolution noted considerable variation in the way biological concepts were presented.

Classrooms using BSCS materials did not necessarily fully incorporate the innovation. We suspect from our interviews with project developers and the general literature that teachers were more willing to change subject matter than their teaching methods. However, a significant portion of 10th grade biology classrooms are measurably different than prior to BSCS. A special analysis of the *Modern Biology* textbook noted it had changed substantially to incorporate BSCS innovation. This textbook and the three BSCS versions are used in about 60 percent of all biology classes.

In summary, we found that the 10th grade *biology* curriculum has changed in the directions advocated by BSCS. Other researchers have found NSF projects produced similar effects on other subject area curricula. We conclude that these development projects have been successful in *diversifying* the science curriculum.

At the elementary level, we showed that the non-textbook materials have been incorporated into almost all publishers' programs. These materials represent a change in the elementary school curriculum encouraging active student participation. Correlational studies showed that teachers' use of the new science curricula instead of the standard textbook is strongly correlated with active student participation.

We stress that these findings describing change in the 10th grade biology curriculum are primarily dependent on evaluation studies having moderate quality of research design. In particular, no study

had random assignment of both teachers and students. Students using BSCS materials performed better on tests sensitive to BSCS objectives than students using conventional materials. Exactly which BSCS innovations account for the differences in the curriculum we cannot say.

#### CHANGES IN EDUCATIONAL INSTITUTIONS

Publishers have been affected by national curriculum development. Small publishers have been encouraged to compete with the dominant publishers. They have introduced alternatives to the standard text and have obtained a substantial share of the market formerly monopolized by a few companies. What this means is an increase in product alternatives as well as the number of publishers competing in the marketplace. The advantage once held by leading publishers has been substantially reduced.

State adoption committees have increased the number of curriculum alternatives they will approve. Specifically, the ruling that only textbooks would be approved was changed due to the inclusion of non-textbook materials in the new curricula.

School districts decentralized their decisionmaking processes to fit the diversity of the new materials. New technical facilities and classroom procedures were adopted to support the demands of the new curriculum.

#### Secondary Impact

Innovations were incorporated into curriculum materials to a far greater extent than first thought. Once the materials published by the national curriculum projects were proven successful in the classroom, commercial publishers incorporated the innovation into their own programs. These findings implied that it was the actual materials embodying the innovation rather than ideas about them that motivated commercial publishers.

The curriculum reform era also fostered simultaneous social and institutional changes that made it more feasible for commercial publishers to include controversial topics or materials. Institutions determine what is taught in the schools and often pose the strongest barriers to curriculum change.

Taken as a whole, the national curriculum projects appear to have been distinctive in that they served the two potential functions of curriculum development. They both translated ideas into materials and also challenged social and institutional barriers to the innovations advocated that existed within the curriculum policy system.

#### RESEARCH DIRECTIONS

(1) More research is needed on the incorporation effects of different school level implementation strategies.

(2) The important issues are to understand if there are any strategies that result in greater incorporation of innovations from national curriculum development, in what situations in local school districts, and at what cost. How can school personnel function to produce curriculum change?

(3) Another important research area is incorporation of innovation in private schools of education, testing services, and teacher certification institutions.

(4) Finally, what is the feasibility of an implementation strategy at the "policy level" rather than at the "school level"? Should national development be limited to *basic* curriculum problems? (The time lag for national development as exemplified by NSF is from five to seven years.)

The policy challenge is to find ways of achieving the full educational potential as represented in materials in the schools. If we start with the cognitive and social developmental needs of children as our basis for reform curriculum, we will stay focused on basics.



## APPENDIX

### The Revisions Analysis

During the revisions analysis, we paired and compared six versions of the *Modern Biology* text published by the Holt Company (i.e., the 1956, 1960, 1963, 1965, 1969, and 1973 versions) to identify subsections that either: (1) remained substantially intact from an earlier edition to a later edition; (2) had been added to the newer edition additions; or, (3) had been deleted from the older edition deletions. Criteria for identifying the changes as well as the analysis follows.

- *Identifying substantially intact subsections.* A subsection is considered substantially intact if either a, b, or c is applicable:
  - (a) The subsection heading in the new edition is the same as or explicitly comparable to a subsection heading appearing in the prior edition.\* Examples of explicitly comparable headings are:
    - How sponges reproduce vs. Sponges reproduce in several ways
    - The nature of carbohydrates vs. What are carbohydrates
  - (b) Over half the key terms and concepts emphasized by bold-face or italic type in the subsection in the new edition are the same as those appearing in the text of the earlier edition. (Note that two or more subsections from an earlier version are sometimes combined to form one subsection in a later version; combinations of subsections into a single subsection are considered substantially intact if this criteria holds.)
  - (c) The main point in over half the paragraphs of the subsection in the new edition are the same as those made

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\* Careful comparison of editions revealed that in cases of explicitly comparable headings, there was typically little change in the actual text of the subsection.

in the text of the earlier edition. (The consideration of combined subsections also holds for this case.)

- ° *Identifying additions* (i.e., subsections of the older edition that have been added to the newer edition). All subsections not coded as substantially intact in the newer edition are considered new subsections or "additions."
- ° *Identifying deletions* (i.e., subsections of the older edition that do not appear in the newer edition). A subsection is considered to be a deletion if a or b are applicable:
  - (a) Over half the key terms in boldface or italic type do not appear in a later version of the text.
  - (b) The main points made in over half the paragraphs of the subsection are not apparent in the later version.

Using these criteria, we compared the 1956 version with the 1960 version to identify subsections in the 1956 version that were no longer in the 1960 version (i.e., "deletions") and subsections that were new to the 1960 version (i.e., "additions"). Proceeding in this way, we identified five sets of deletions and additions or textual changes: 1956-1960; 1960-1963; 1963-1965; 1965-1969; 1969-1970. Each set of deleted and added subsections represent the textual changes in one edition of the *Modern Biology* textbook. In other words, the 1956 deletions, 1960 additions are text changes in the 1960 edition of *Modern Biology*; the 1960 deletions-1963 additions are changes in the 1963 edition.

#### Magnitude of the Changes

Table A.1 displays the numbers of subsections added and deleted in each of the *Modern Biology* version lengths. There were a total of 560 subsections changed during the period covered by the study. Three hundred (54 percent) of the changes resulted from adding new subsections of the text while 260 (46 percent) of the changes resulted from the deletion of material that had appeared in the prior edition. There was a 25 percent growth in the amount of written text in the 1973 edition as compared with the 1956 edition.

Table A.1  
SUBSECTIONS ADDED TO AND DELETED FROM  
MODERN BIOLOGY OVER TIME

|                                                                                                     |                                            | Year   |        |        |        |        |       |         |
|-----------------------------------------------------------------------------------------------------|--------------------------------------------|--------|--------|--------|--------|--------|-------|---------|
|                                                                                                     |                                            | 1956   | 1960   | 1963   | 1965   | 1969   | 1973  | Total   |
| <u>Additions</u>                                                                                    | Number of subsections                      | --     | 83     | 6      | 132    | 46     | 33    | 300     |
| Subsections included in the given year that did not appear in the previous edition                  | Total length* of subsections               | --     | 475.6  | 50.6   | 1104.3 | 375    | 247.3 | 2252.8  |
|                                                                                                     | Average length* of subsections added (in.) | --     | 5.73   | 8.43   | 8.36   | 8.15   | 7.49  |         |
| <u>Deletions</u>                                                                                    | Number of subsections                      | 12     | 10     | 169    | 16     | 53     | --    | 260     |
| Number of subsections appearing in given year that were deleted when the next edition was published | Total length* of subsections               | 70.5   | 64.0   | 876.25 | 104.3  | 226.9  | --    | 1341.95 |
|                                                                                                     | Average length* of subsections deleted     | 5.88   | 6.40   | 5.18   | 6.52   | 4.28   | --    |         |
| Textbook length*                                                                                    |                                            | 5264.8 | 5669.9 | 5698.5 | 5630.2 | 6561.0 |       |         |

\* All measures of length are reported in column inches. Because the column width changed when the editions were revised, the figures have been adjusted to afford comparability and represent a 2-1/2 inch column width.

\*\* Not available.

Table A.1 gives two indicators of the magnitude of the changes made in the various revisions of *Modern Biology*. By dividing the total inches of written text in a given year by the total number of written text in new subsections, it is possible to compute the percent of written material not appearing before. Similarly, by dividing the number of inches of the subsections deleted from the new edition into the total number of inches of the previous edition, it can be determined just how much of the previous edition was deleted from the updated version.

#### Pattern of Change

The data in Table A.1 and A. 2 reflect two striking irregularities. First is the relatively large proportion of change in the 1965 edition of *Modern Biology*. This edition of *Modern Biology* accounts for 303 subsection changes, about 54 percent of the total change observed over the 17-year period spanned in our analysis. Close to 20 percent of the written text appearing in 1965 was new to the *Modern Biology* series. The revision processes for the 1965 edition resulted in the elimination of about 15 percent of the written text from the previous (1963) edition. Thus, these changes from 1963-1965 were far in excess of the amount of change required to establish a new edition copyright.\* This is in contrast to all the other revisions

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\*The copyright laws are vague with respect to how much change is necessary for a new copyright to be issued. The copyright application provides two lines for the applicant to describe what is new in an updated version of a previously published book. New matter may consist of compilation, translation, abridgment, editorial revision, and the like, as well as additional text or pictorial matter. Thus, it is possible for an updated version to only differ from the previous edition by virtue of editorial changes or changes in some form of the pictures. It is common knowledge that the publisher of a highly successful series is most likely to make only minor changes when revising that series as there is generally little to be gained by modifying a product that has enjoyed continued market success. If the majority of teachers are satisfied with a series, a publisher may risk reducing the market for a textbook when the new edition is substantially different from the previous edition.



Table A.2  
MAGNITUDE OF SUBSECTION CHANGES IN  
*MODERN BIOLOGY* OVER TIME

| <u>Year of Edition</u> | <u>Percent of Text<br/>That Was New<br/>to the Edition</u> | <u>Percent of Text<br/>That Did Not<br/>Appear in the<br/>Subsequent<br/>Edition</u> |
|------------------------|------------------------------------------------------------|--------------------------------------------------------------------------------------|
| 1956                   | --                                                         | 1.3*                                                                                 |
| 1960                   | 8.4                                                        | 1.1                                                                                  |
| 1963                   | 0.9                                                        | 15.4                                                                                 |
| 1965                   | 19.6                                                       | 1.9                                                                                  |
| 1969                   | 6.0                                                        | 3.6                                                                                  |
| 1973                   | 3.8                                                        | --                                                                                   |

\* Estimated figure

reported where the percent of new written text was more closely in line with copyright requirements. Noteworthy, however, is the exceedingly small amount of new text in the 1963 version. Only one percent of the written material appearing in 1963 was new to the *Modern Biology* series and the subsection changes observed for that edition accounted for only three percent of total changes evidenced in our study.

The second striking irregularity also centers on the 1963 and 1965 versions of *Modern Biology* in that the timing of the publication dates of these versions deviates from usual timing between new editions. Publishers normally put out a revised edition of a successful textbook once every four years. Four years was the space between the 1956 and 1960 editions, the 1965 and 1969 editions, and the 1969 and 1973 versions. However, in the first five years of the 1960s, Holt published two new *Modern Biology* editions. The publication of the first of these revised editions coincided with the release of the first editions of the BSCS biology programs. The second of these "revised" editions reflects substantial change and followed the publication of BSCS by only two years. It would appear, then, that the second edition came about due to the wide success of the BSCS program.

### Levels of Emphasis Analyzed

The second stage of the content study determined which changes were consistent with the BSCS developers' emphasis on biological levels other than the organ-tissue core. We categorized additions and deletions according to their content emphasis and noted if changes reflected the innovation.

### Extent of Content Redistribution

Data analysis (Table A.3) indicates that *Modern Biology* has undergone a change in content emphasis reflecting reforms advocated by the BSCS group. The changes for any single year are distributed among several different content categories with no category over time dominating the changes. Even though the changes in emphasis categories may seem relatively small in any given year, cumulative changes for all categories over several editions resulted in a noteworthy redistribution of content. As Figure A.1 indicates, a cumulative total of 335 subsection changes, *consistent* with the BSCS approach, were found in editions published from 1960 to 1973, while there were only 198 subsection changes *inconsistent* with the BSCS approach during the same period. The greatest change took place in the 1965 *Modern Biology* edition when a net total of 139 BSCS-consistent changes were found. Since BSCS was first published in 1963, there have been a total of 312 changes consistent and 137 changes inconsistent with the BSCS program.

The data presented in Table A.4 converts the subsection changes into column-inches of text to illustrate the magnitude of the changes: they show that a net total of 987.1 column-inches of written text or approximately 17 percent of the written text has been redistributed in a manner consistent with the incorporation of the BSCS innovation.

Table A.3

PATTERNS OF EMPHASIS IN DELETED AND  
ADDED *MODERN BIOLOGY* SUBSECTIONS

| Category                             |            | Edition |      |      |      |      | Cumulative<br>Total |
|--------------------------------------|------------|---------|------|------|------|------|---------------------|
|                                      |            | 1960    | 1963 | 1965 | 1969 | 1973 |                     |
| Organ-Tissue-<br>Morphology          | Add        | 30      | 0    | 32   | 20   | 8    | +37                 |
|                                      | Delete     | 3       | 3    | 32   | 3    | 12   |                     |
|                                      | Difference | +27     | -3   | 0    | +17  | - 4  |                     |
| Applied<br>Field                     | Add        | 28      | 0    | 12   | 3    | 15   | -75                 |
|                                      | Delete     | 2       | 6    | 89   | 5    | 31   |                     |
|                                      | Difference | +26     | -6   | -77  | - 2  | -16  |                     |
| Molecular-<br>Cellular               | Add        | 5       | 6    | 36   | 8    | 5    | +53                 |
|                                      | Delete     | 0       | 1    | 4    | 1    | 1    |                     |
|                                      | Difference | + 5     | +5   | +32  | + 7  | + 4  |                     |
| Behavior-<br>Population-<br>Biome    | Add        | 13      | 0    | 55   | 12   | 9    | +46                 |
|                                      | Delete     | 3       | 1    | 25   | 3    | 11   |                     |
|                                      | Difference | +10     | -1   | +30  | + 9  | - 2  |                     |
| Science<br>Discipline                | Add        | 15      | 0    | 6    | 5    | 5    | 7                   |
|                                      | Delete     | 1       | 2    | 13   | 5    | 3    |                     |
|                                      | Difference | +14     | -2   | - 7  | 0    | + 2  |                     |
| History-<br>Scientific-<br>Processes | Add        | 2       | 0    | 5    | 3    | 0    | -14                 |
|                                      | Delete     | 1       | 0    | 21   | 1    | 1    |                     |
|                                      | Difference | + 1     | 0    | -16  | + 2  | - 1  |                     |
| Non-<br>Substantive                  | Add        | 0       | 0    | 0    | 1    | 0    | - 4                 |
|                                      | Delete     | 2       | 0    | 3    | 0    | 0    |                     |
|                                      | Difference | - 2     | 0    | - 3  | + 1  | 0    |                     |

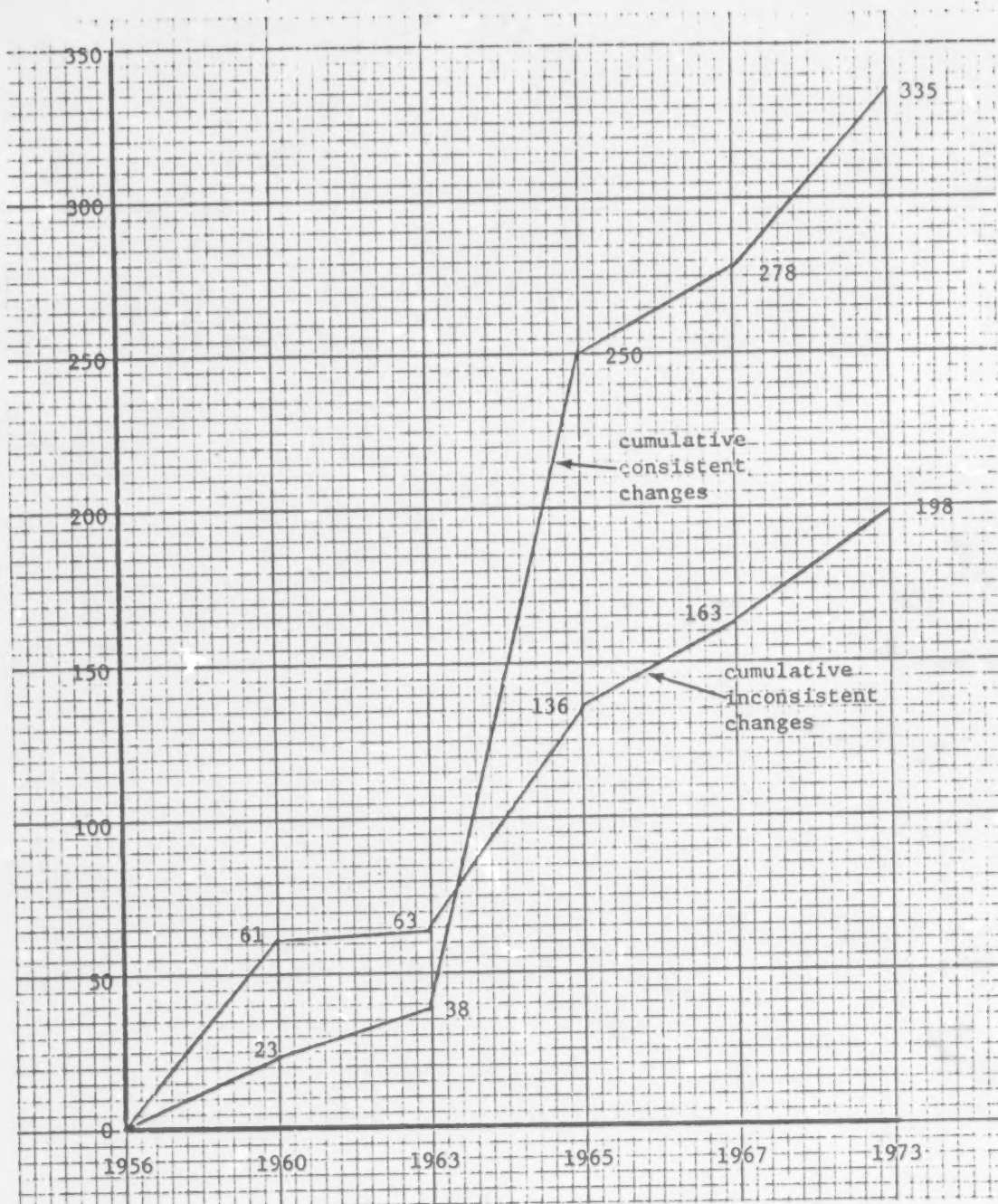


Fig. A.1: Cumulative subsection changes in *Modern Biology* consistent and inconsistent with the BSCS approach.



Table A.4

COLUMN INCHES OF ADDED AND DELETED SUBSECTIONS BY CONTENT CATEGORIES<sup>a</sup>

| Category                          |            | Edition |       |        |       |       | Total<br>63-73 | Cumulative<br>Total |
|-----------------------------------|------------|---------|-------|--------|-------|-------|----------------|---------------------|
|                                   |            | 1960    | 1963  | 1965   | 1969  | 1973  |                |                     |
| Organ-Tissue-<br>Morphology       | Add        | 171.0   | 5.7   | 267.5  | 163.0 | 59.9  | 255.4          | 40.9                |
|                                   | Delete     | 17.4    | 6.4   | 163.2  | 19.5  | 51.6  |                |                     |
|                                   | Difference | 153.6   | - .7  | 104.3  | 143.5 | 8.3   |                |                     |
| Applied<br>Field                  | Add        | 159.6   | 0     | 100.3  | 24.5  | 112.4 | -401.7         | -253.7              |
|                                   | Delete     | 11.6    | 19.2  | 453.9  | 32.5  | 133.3 |                |                     |
|                                   | Difference | 148.0   | -19.2 | -353.6 | - 8.0 | -20.9 |                |                     |
| Molecular-<br>Cellular            | Add        | 28.5    | 50.4  | 301.0  | 65.2  | 37.5  | 416.5          | 44.5                |
|                                   | Delete     | 0       | 6.4   | 20.4   | 6.5   | 4.3   |                |                     |
|                                   | Difference | 28.5    | 44.0  | 280.6  | 58.7  | 33.2  |                |                     |
| Behavior-<br>Population-<br>Biome | Add        | 74.1    | 0     | 459.8  | 97.8  | 67.4  | 424.3          | 48.1                |
|                                   | Delete     | 17.4    | 6.4   | 127.5  | 19.5  | 47.3  |                |                     |
|                                   | Difference | 56.7    | - 6.4 | 332.3  | 78.3  | 20.1  |                |                     |

<sup>a</sup>Calculations are based on average subsection lengths as detailed in Table 5.

Table A.5

SAMPLE CRITERIA FOR CODING THEMES

Examine each subsection to determine if one or more of the four themes described below are reflected in the subsection. Themes should be coded only when explicitly apparent; that is, when it is possible to underline the words that indicate the presence of the theme. Not every subsection will evidence a theme.

Theme 1: Complementarity of Structure and Function

- o Check this theme category if the subsection relates biological structure to biological function in such a way as to illustrate why a particular structure is suited to a particular function.
- o Check this theme category if the subsection demonstrates that biological structure can be used to infer biological function.

Theme 2: History-Scientific Processes

- o Check this theme category if the subsection discusses the general methods through which scientific knowledge is generated.
- o Check this theme category if the subsection presents the details of a study or group of studies undertaken to explore questions of scientific interest.
- o Check this theme category if the subsection discusses how people's thoughts about or knowledge of aspects of biology have changed at different points in history.
- o Check this theme category if the subsection discusses the nature of science, the kinds of questions different scientists attempt to answer.

Theme 3: Complementarity of Organism and Environment

- o Check this theme if the subsection explains how the function or dynamics of a biological entity (e.g., cell, organ, individual, population) are influenced by its environment.

- o Check this theme if the subsection explains how a biological entity (e.g., cell, organ, individual, population) modifies the environment in which it exists.

Theme 4: Change of Living Things Through Time

- o Check this theme category if the subsection describes the history of organisms--the sequence of events in past time from which the biological present has had its origins.
- o Check this theme category if the subsection describes the processes through which organisms evolve over time (e.g., natural selection, adaption, mutation).

Table A.6

SAMPLE THEMES FROM NSF SCIENCE CURRICULUM PROGRAMS

CHEMICAL EDUCATION MATERIAL STUDY (CHEM STUDY)

Substance Themes

- energy and its role in chemical reactions
- conservation of mass-energy in terms of the conservation of atoms and electrical charge
- kinetics and mechanics of chemical reactions
- dynamic equilibria
- competitive factors acting in chemical systems in general
- electron structure and the geometrical arrangement of atoms

Process Themes (stated in terms of student abilities)

- to accumulate information through experimental observations
- to organize information and to observe regularities: to evaluate and interpret data
- to use a model system to account for observed behavior
- to communicate his findings from observations to others
- to appreciate the meaning of uncertainty in science or the absence of certainty
- to recognize that a theory or law need not be correct in every context to be useful in a limited context

BIOLOGICAL SCIENCE CURRICULUM STUDY (BSCS)

Substance Themes

- change of living things through time: evolution
- diversity of type and unity of pattern in living things
- the genetic continuity of life
- the complementarity of organism and environment
- the biological roots of behavior
- the complementarity of structure and function
- regulation and homeostasis: preservation of life in the face of change

Process Themes

- science as enquiry
- the history of biological conceptions

SOURCE: Paul DeHart Hurd, *New Directions in Teaching Secondary School Science* (Chicago: Rand McNally and Company, 1971), pp. 79-80.



Table A.7

THE INCORPORATION OF THE THEME "COMPLEMENTARITY OF ORGANISM  
AND ENVIRONMENT" INTO *MODERN BIOLOGY*

The excerpts below are examples of how the theme "complementarity and environment" was incorporated into newly added subsections in the 1965 edition of *Modern Biology*.

At the Molecular/Cellular Level:

External factors that influence diffusion rates. In addition to molecular concentration, two other factors influence the rate at which diffusion occurs. One of these is *temperature*. The higher the temperature the greater the speed of molecular movement. This diffusion occurs from an area of higher temperature to one of lower temperature. Similarly, *pressure* accelerates molecular movement, resulting in diffusion from a region of higher pressure to one of lower pressure.... (p. 78)

At the Organ/Tissue/Morphology Level:

Dynamic balance in the endocrine glands.

....Besides the influence of glands on one another, there are two other factors operating to produce the delicate check-and-balance system in body chemistry.

In the first of these factors, called *feedback*, the accumulation of a substance in the blood automatically cuts down its production by the endocrine gland. For example, remember that parathormone regulates the level of calcium in the body. The concentration of calcium in turn regulates the production of parathormone. When the calcium level in the body drops, the secretion of parathormone increases to restore the calcium level. When the proper level is reached, the calcium influences the parathyroids to decrease their secretion. This same kind of feedback occurs in the other glands and between various glands. In this way a balanced state is automatically maintained in the normally functioning body. (p. 646)

At the Behavior/Population/Biome Level:

What is the value of periodicity? As you are now well aware, an organism must be able to meet environmental changes in order to survive. You have seen many ways in which various organisms adjust to changes in the environment. The establishment of a synchronized rhythm for any entire population is of value for the survival of the species. The behavior of swarming grunion insures the aggregation of males and females so the eggs can be fertilized.

Male and female gametes of the oyster are shed into the surrounding water at the same time. Even though a female oyster may produce 114,000,000 eggs, her efforts would be futile if a neighboring male did not release sperm at the same time. (p. 693)

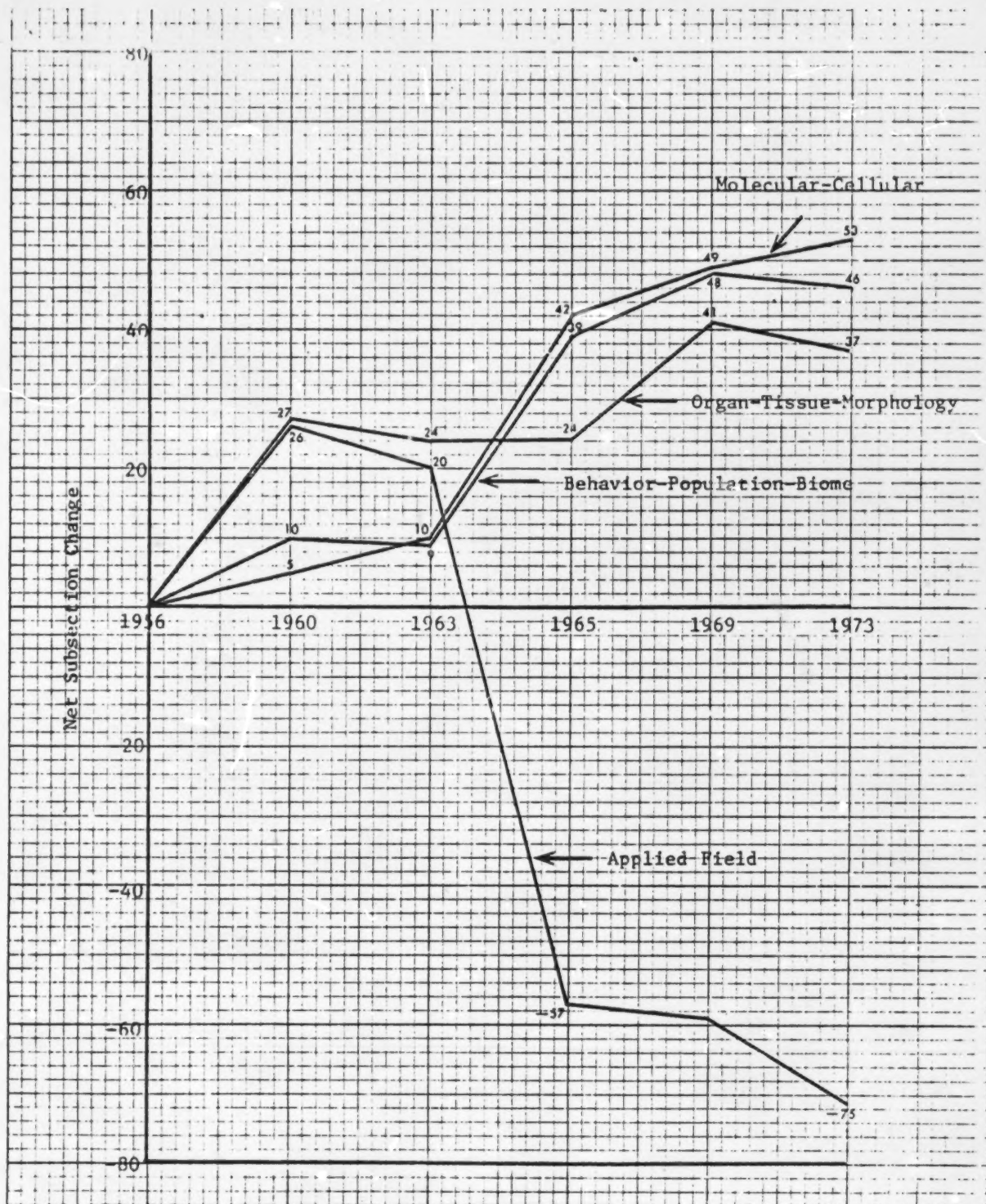


Fig. A.2: Net changes in four emphasis categories since 1956

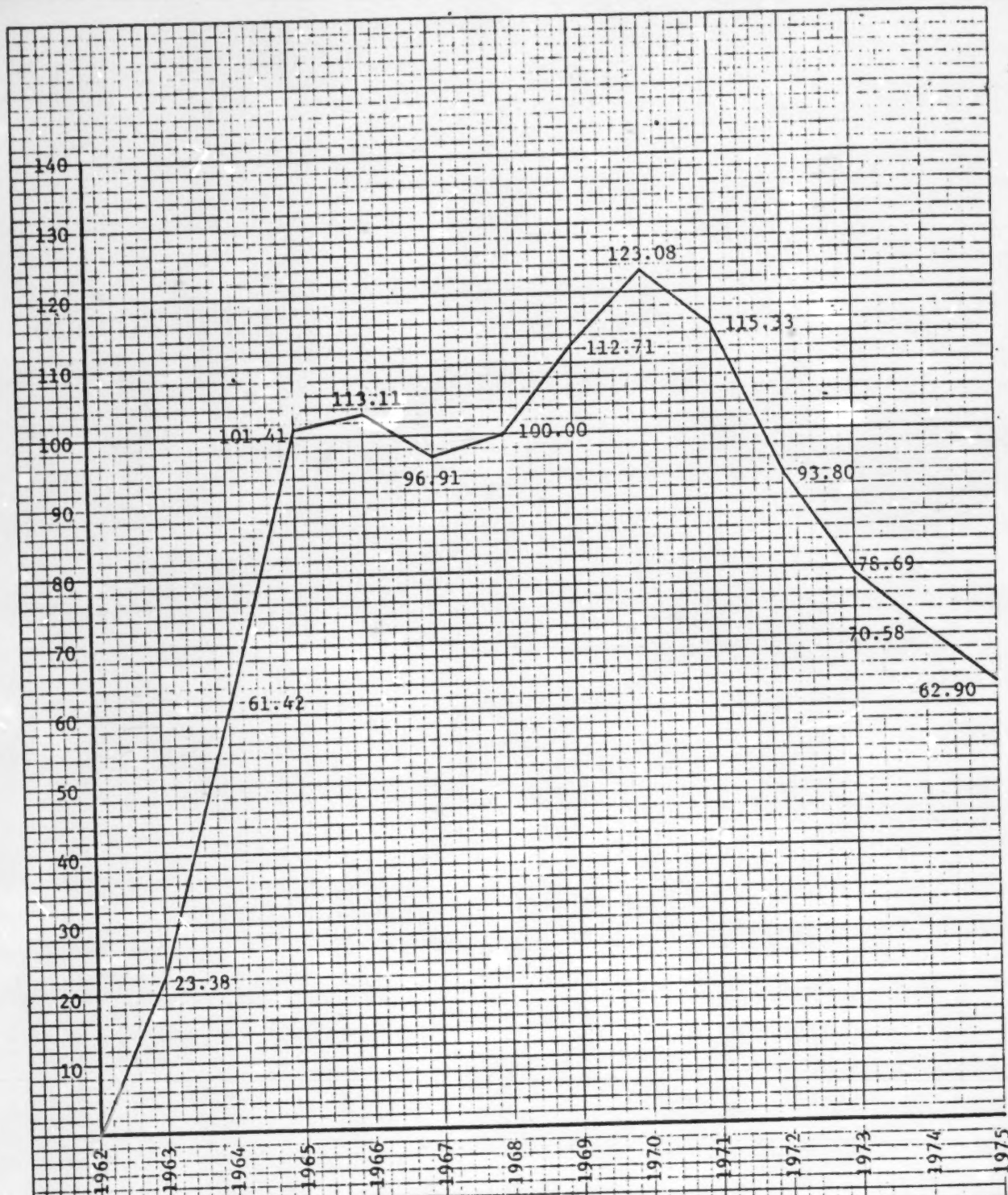


Fig. A.3: Estimated Student Usage of BSCS Versions Over Time

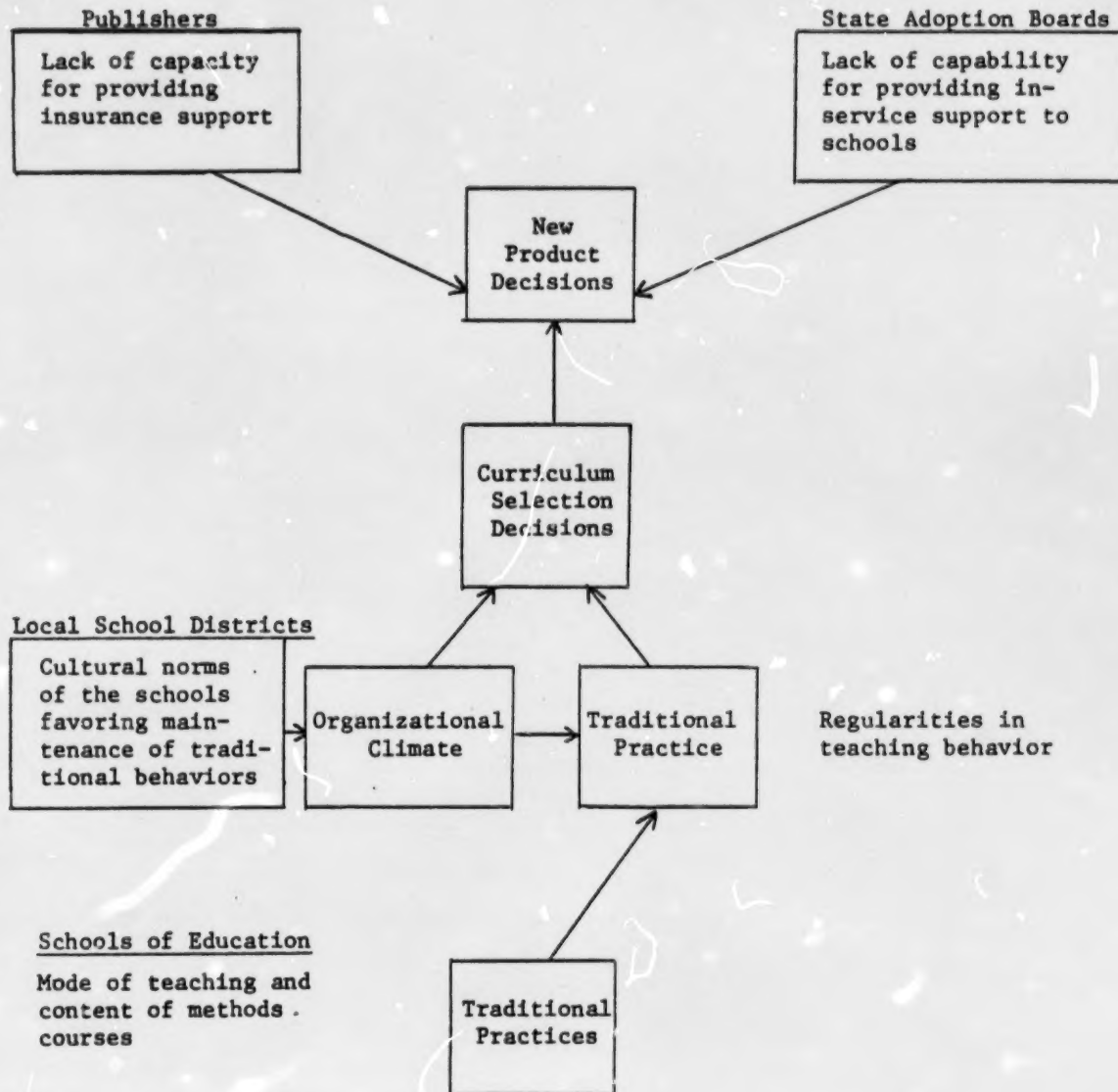


Table A.8

## THE SCIENCE CURRICULUM INNOVATIONS STUDIED

| <u>Curricular Dimension</u>                             | <u>General Innovation<br/>of the NSF Programs</u>                                                                                            | <u>NSF Programs Having<br/>the Innovation</u>                                                         | <u>Example of the Effect<br/>in the Classroom</u>                                                                                                                                                                                                                              | <u>Commercial Programs<br/>Examined</u>                                                                     |
|---------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------|
| Subject Matter Time<br>Allocations: Content<br>Strands  | Update and redistribute<br>subject matter content<br>to more accurately re-<br>flect the current state<br>of the scientific dis-<br>cipline. | BSCS (Biology)<br>CBA (Chemistry)<br>CHEM Study (Chemistry)<br>ESCP (Earth Science)<br>PSSC (Physics) | Biology students spend<br>more time studying mole-<br>cular biology, cellular<br>biology, ecology and<br>human behavior. Text-<br>books include less taxo-<br>nomy and general physiology.                                                                                     | Holt, Rinehart and Winston,<br><i>Modern Biology</i> , 1956, 1960,<br>1963, 1965, 1969, 1970 edi-<br>tions. |
| Skills Emphasis:<br>Intellectual Skills                 | Organize materials<br>around a few conceptual<br>schemes that are central<br>to understanding the<br>scientific discipline.                  | BSCS (Biology)<br>CBA (Chemistry)<br>CHEM Study (Chemistry)<br>ESCP (Earth Science)<br>PSSC (Physics) | Biology texts give increased<br>emphasis on a few general<br>patterns and concepts appli-<br>cable to all levels of bio-<br>logical organization (e.g.,<br>structure is related to<br>functions); there is decreased<br>emphasis on memorizing minor<br>details at all levels. | Holt, Rinehart and Winston,<br><i>Modern Biology</i> , 1956, 1960,<br>1963, 1965, 1969, 1970 edi-<br>tions. |
| Materials Presenta-<br>tion: Non-textbook<br>Formatting | Make kits or other<br>manipulatives central<br>to the curriculum.                                                                            | ESS<br>HSP<br>SAPA<br>SCIS<br>USMES                                                                   | Students spend classroom time<br>participating in experiments<br>and other activities designed<br>both to develop an understand-<br>ing of scientific principles<br>and to convey scientific know-<br>ledge. Quiet desk work is<br>minimized.                                  | Elementary Programs listed<br>in <i>El-Hi Textbooks</i> in print<br>1955-1975.                              |

KEY EDUCATIONAL INSTITUTIONS AND CURRICULUM INNOVATION



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